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HE AIRSHIP SERVICE ON LAKE LUCERNE.

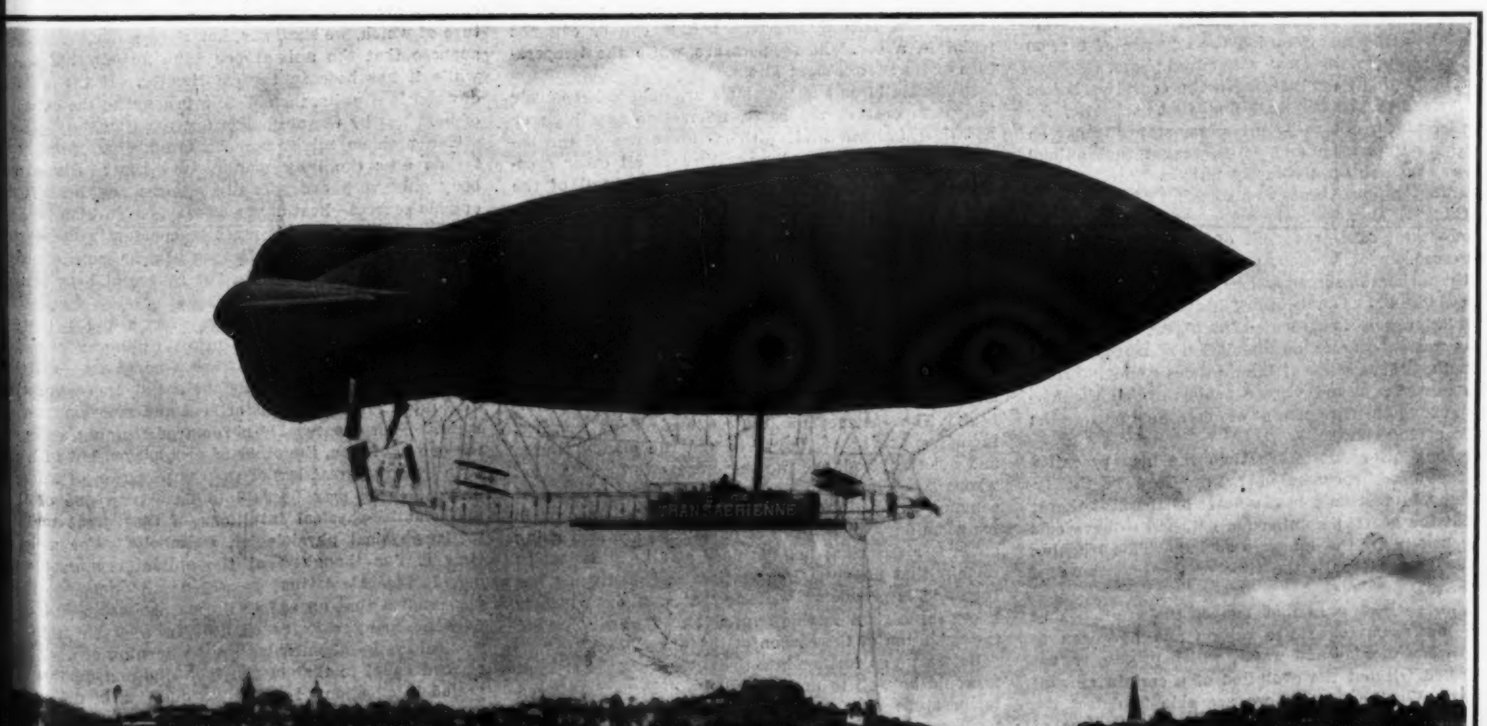
y Our Berlin Correspondent.

To have access to the nknown joys of air avel, which so far has en the privilege of but w, is doubtless the wish many tourists wont to dulge in every fancy aginable. In order to commodate such a dere as this, a company nnected with the conructors of the Zeppelin rship some months since ganized a passenger rvice, which unfortunely met with an untime- end. Less ambitious though hardly any fer against any risk failure, the passenger hts recently inaugurd on the Lake of Lune, in one of the most utiful parts of Switzerd, will enable any tour- visiting that country to te the impressions of a age in mid-air. As these flights are only made in orable weather, the pleasures of the amateur aerot will not be spoiled by any fear. The constructors of some of the most famous French dirigible balloons ("Ville de Paris," "Ville de Bordeaux," "Ville de Nancy," "Clément-Bayard," "España," etc.) have placed at the disposal of the Aéro Company a balloon of the same type, the "Ville de Lucerne I.," a beautiful aerial cruiser of the non-rigid type, 60 meters (196.8 feet) in length and 12 meters (39.4 feet) in maximum diameter. This balloon, 4,500 cubic meters (158,913 cubic feet) in capacity, has been made of a double caoutchouc-lined fabric, and is filled exclusively with pure hydrogen generated on the spot in a special gas works.

The body of the "Ville de Lucerne" is spindle shaped, and is provided at the rear end with a novel tail rudder, which, while increasing the stability of the system, leaves the purity of its lines unimpaired.

The gondola, 30 meters (98.4 feet) in length, is made entirely of steel tubes; its quadrangular cross section has been designed with a view to insuring an equal resistance throughout its length. In its central part the cabin is arranged for the mechanics, pilots, and passengers. It carries the rudders

GREAT SHED OF THE PASSENGER SERVICE DIRIGIBLES, LUCERNE PARK.



VIEW OF A PASSENGER SERVICE DIRIGIBLE BALLOON STARTING FROM LUCERNE PARK FOR VOYAGE OVER LAKE LUCERNE.

controlled by the pilot, who has also within his reach and control any organs required for steering the course and measuring the altitude.

The suspension of the gondola consists of a substantial strip of linen glued or sewed to the body of the balloon and to which are fixed the ends of the carrying ropes. To these ends are connected the steel cable slings attached by their lower ends to the gondola. The resistance of the ropes is such that they are able to deal with a tension ten times higher than the normal figure, thus excluding any risk of rupture.

The gasoline motor is of the 4-cylinder type, and yields an output of 110 horse-power at the propeller. The transmission of energy from the motor to the propeller is effected by a longitudinal shaft actuating the last, and the speed of which is reduced by a proper gearing. The propeller only comprises two wings of great diameter (5 meters, 16.4 feet); it is made of nutwood throughout, and its maximum speed is 400 revolutions per minute. Owing to this moderate speed, as well as to its form and construction, the propeller is effectually protected against any risk of rupture. It can be at will thrown in and out of gear.

The "Ville de Lucerne I.," with a traveling speed of 36 miles per hour, is able to carry on board, in addition to her crew, 10 to 12 passengers, with the stores of fuel and ballast required for a voyage of five hours without landing. She may thus safely risk herself up to the highest altitudes, reaching most readily a height of 5,000 feet above the level of the sea.

The floats fixed to the bottom of the gondola enable the airship to come down smoothly and to swim on the surface of the lake, while being able at any moment to start upon a new flight.

The summer station of the "Ville de Lucerne I," the new aeronautical park of Lucerne, is situated at about half a mile from the city on the banks of the lake, in incomparable scenery, and sufficiently near to allow the tourist to acquire any sensation of aerial navigation without having to travel any long distances. In fact, a short walk or a few minutes' travel in a motor boat will bring him alongside the balloon.

A balloon shed of majestic dimensions, which readily accommodates two balloons at a time, protects the dirigible against the effects of bad weather.

The installation of this aeronautical park has added a new attraction to the many beauties of this paradise of tourists. The crew of the airship is chosen among the most experienced pilots and airship mechanics, so as to afford to passengers almost absolute safety.

ANIMAL HEAT.

LIVING CHEMICAL ENGINES.

BY DAVID FRASER HARRIS, B.SC.

One of the most noticeable features of an animal is that it can produce heat. Biologists long ago came to the conclusion that it was by the oxidation chiefly of the carbon and hydrogen in or by the living substance that animal heat was generated. By "long ago," we mean the time of the great chemist Lavoisier, who, though he made some mistakes in animal chemistry, certainly understood that animal heat and the heat of combustion were alike in this that they were both due to oxidations. Before the discovery of oxygen by Priestley and Lavoisier, this position could not have been attained to, although both Lower and Mayow of Oxford by 1669 had arrived at the conclusion that there was something in the atmosphere (Mayow called it "nitro-aerial particles") which was essential for the maintenance of animal life, and for all sorts of combustions. This was the dawn; Priestley and Lavoisier were morning stars; we live to-day in the high noon of the understanding of animal heat.

The chemical view of the origin of animal heat was, however, lost sight of by two such eminent thinkers of the eighteenth century as Boerhaave and Hales, who held that the heat of the body was due to the friction between the blood corpuscles and the blood, and between them and the walls of the vessels. This is known as the iatro-physical view of animal heat. One can only mention the famous view of Stahl (1687), that the "principle of fire was phlogiston," a Teutonic "will-o'-the-wisp" that retarded the advance of thermo and bio-chemistry for quite a hundred years.

But if by "long ago" we mean the centuries before the Christian era, we shall find that Aristotle, for instance, who seems to have had something to say on everything in heaven and earth, taught that animal heat was something absolutely unique. Aristotle believed that animal heat was something *sui generis*, something of an absolutely different order from heat of non-vital origin—the heat of a fire, or of a gas compressed, or of friction, for instance. He thought that the ultimate source of bodily heat was an eternal essence, the source of being of heaven and the stars, which latter were imagined as intelligent existences.

This was, of course, the foundation of astrology, the notion that these celestial intelligences could interfere in human affairs, and were capable through the harmony of their movements of creating music—the "music of the spheres."

For long after Aristotle's time the idea prevailed that the blood, recuperated by the food in the intestines, was kept fluid in the heart by the heat there; but that the heart, becoming too hot, had to have cold air sucked in by the lungs to cool it. This teaching actually lingered until the time of Harvey who died in 1657.

Our present view is that one of the attributes of living matter is to oxidize carbon and hydrogen to form carbon dioxide and water, which process cannot be effected without the evolution of a certain amount of heat. Whether or not we are able to detect the heat so produced is quite another matter. One of Lavoisier's original ideas was that all the animal heat was produced in the blood of the lungs; that the lungs were the furnace of the body, and that the heat was carried thence by the circulating blood. We now know that the blood is responsible for the production of very little heat indeed, and are quite certain that it is in the muscles that by far the greatest amount of bodily heat is manufactured. That a bloodless muscle could produce heat even after it was cut out of the body was proved for the first time by Helmholtz in 1848.

Everyone is familiar with the distinction between cold-blooded and warm-blooded animals, but this classification has lost its meaning. We now speak of animals which are able to maintain a constant temperature and of those which are unable to do so, and these answer to the old warm and cold-blooded animals respectively. Those animals whose body temperature rises and falls as the temperature of their environment rises and falls are now known as poikilothermic, and those which are able to maintain a constant temperature, however much the temperature of the environment rises or falls, are known as homoiothermic animals. This new classification has been found necessary because of facts such as the following: The temperature inside a hive of bees (and insects are classed as "cold-blooded") may even in winter time rise 21 deg. C. (69.8 deg. F.) above that of the outer air; a mammal (a "warm-blooded" animal) has, when hibernating, a temperature almost the same as that of its cold environment; the temperature of a newly-born mouse goes up and down with that of its surroundings; a frog or fish placed in warm water becomes as warm as the water. In other words a cold-blooded animal can, under certain circumstances, become warm-blooded, and a warm-blooded animal can become cold-blooded, so that all seems confusion.

The important point is not whether the animal feels hot or cold to human touch at any given moment of observation, but whether the animal can or can not maintain a constant temperature while the temperature of its environment alters.

In health, birds and mammals are able to keep their body temperature the same, no matter how high or how low (within limits) the temperature of the environment goes. The temperature of all other creatures rises with a rise and falls with a fall of the outside temperature. In this latter class, we must include the human infant, hibernating mammals and newly-hatched birds.

The power possessed by all living things, plants included, to produce heat as one of the manifestations of their vitality is referred to as thermogenesis. No doubt the actual amounts of heat produced by different animals are very different: a fish in unit time per unit of its weight is producing vastly less heat than a man, and a man less than a bird; but they are all producing heat. The thermogenic centers are chiefly muscles, including the heart, the liver and the glands; these, and not the blood, are the thermogenetic foci. A frog whose blood has been replaced by a weak solution of common salt still continues to excrete carbon dioxide for some days, showing that oxidations are still going on in it although it has no blood at all. It is just as certain that an animal producing carbon dioxide has been and is producing heat, as that a candle which is liberating carbon dioxide is producing its heat through the oxidation of the carbon of its fat.

Before we go further into the subject of animal heat, it would be well to understand the difference between temperature and quantity of heat. A difference of temperature between two bodies, A and B, is the expression of the fact that heat is leaving A for B or *vice versa*. If two bodies are at the same temperature, no heat will pass from the one to the other. Temperature is of course usually measured by the visible expansion of some substance, mercury or alcohol, which can take in heat from a hotter body, or on the other hand allow heat to leave it for a colder one. Temperature is to heat what potential is to electricity. Temperature tells us nothing about quantity of heat, but merely whether heat is or is not leaving a given body, and, in a certain sense, how fast it is leaving it. Several things all of the same temperature may, however, feel very different to us on our handling them; some will feel warm, some cold. For instance, the marble mantelpiece and a "Tweed" coat may be at the same temperature as tested by a thermometer, yet the former feels cold compared with the latter. The chief reason is that marble is a good conductor of heat compared with the coat, and abstracts from our skin so much more heat in a given time than does the coat. Thus, getting in between linen sheets is so much "colder" than getting into blankets, because linen is so much better a conductor of heat than is wool.

Measurement of the quantity of heat is effected by an instrument known as the calorimeter. The principle of this is that the heat produced by any particular substance is all absorbed by a known weight of water, which is, in consequence, raised a certain number of degrees in temperature. A calorie, or unit of heat, is defined as the quantity of heat transferred to one kilogramme of water (2.2 pounds) in order to raise it 1 deg. C. in temperature. A water calorimeter is, then, essentially a metal box immersed in a known quantity of water. To ascertain how much heat an animal gives out in a certain time, it is only necessary to place it in the inner box, which is of course properly ventilated. The heat that radiates from its skin is conducted through the box to the water, the heat of its expired air is absorbed by the water, the temperature of which, we shall say, has risen n deg. We shall suppose that the animal has done no external work while it has been in the calorimeter. If the weight of water is W units, then $W \times n$ is equal to the calories of heat lost by the animal in a given time.

The problem might now be faced, from what materials does the body manufacture heat? Since the body only very exceptionally absorbs any heat from outside sources—heat of the Tropics or Turkish bath—it is quite clear that it must be constantly taking in the wherewithal to manufacture heat so continuously. Except in starving animals, the source of heat is the oxidation of the food.

Just as a steam engine transforms the potential chemical energy of the coal into the kinetic forms of energy—heat and external work (movement)—so the animal body transforms the potential energy of the food into the active forms of heat and muscular movement. Both are machines for transforming energy; the one is of iron, the other of protoplasm, but in both equally is the great law of the Conservation of Energy obeyed. This may be said to have been one of the mathematico-physical intuitions of that great mathematico-physical physiologist, Helmholtz. For a long time it was thought that the animal organism was outside the pale of that great generalization, but it is now known that an animal in a calorimeter will produce as many calories of heat in a given time as would have been generated by the burning of a weight of food equal to that of the food digested during the period in question. It is only a question of difference of rate in the setting free of the heat; in burning it we get all the heat out at once; in digesting it we get out just as much heat, but it is liberated much more slowly. The inhabitants of cold countries are pre-eminently fat-eaters; the notion that fats give heat and sugars energy is probably not altogether fallacious.

The actual amount of heat that each adult loses per twenty-four hours is, in round numbers, about three thousand calories, the ultimate source of which is the oxidation of the various oxidizable chemical elements in the food of twenty-four hours. Knowing that one gramme of protein (flesh) yields us 4.1 calories, one gramme of sugar 4.1, and one gramme of fat 9, it is not difficult to construct a dietary containing poten-

tially the necessary heat. We have further to know that the ratio of the weight of nitrogen-containing to non-nitrogen-containing substances must be about 1 to 3.5 or 4.5.

The portions of the total heat loss borne by each system have been determined as follows:

Heat radiated and conducted from the skin, 2,190 calories or 73 per cent.

Heat lost in evaporating water from the skin, 435 calories or 14.5 per cent.

Heat lost in evaporating water from the lungs, 216 calories or 7.2 per cent.

Heat lost in warming the expired air to body temperature, 105 calories or 3.5 per cent.

Heat lost in warming the dejecta, 54 calories or 1.8 per cent.

In human beings, then, the skin is the system of heat loss, being responsible for the loss of 87.5 per cent of the total heat lost. This is not so in some animals; the dog, for instance, whose hairy coat does not permit its skin to perspire. The dog loses heat largely by its expired air, and by the radiation and evaporation of water from its tongue; thus it pants and puts out its tongue on a hot day.

Obviously our clothes prevent the loss of heat, and the more effectually as they are bad conductors of heat. For this reason flannel, wool and furs are so much "warmer" than linen or cotton, materials from the vegetable kingdom, and therefore not the natural clothing of animals.

An animal is not only a transformer of energy, but it is the most economical transformer known; for whereas in the very best steam engine we obtain about 12 per cent of the original potential energy as motion (external work), in the animal we get as much as 25 per cent in the form of useful work. And whereas in the engine a great deal of the heat set free is lost or wasted from the engineer's point of view, the animal heat, so far from being wasted, is all essential to the protoplasm to provide it with the optimum temperature for the performance of its vital activities.

The muscles as energy transformers differ from an engine in possessing two distinct powers, heat-producing and work-producing, or the thermogenic and dynamogenic respectively. Now the interesting thing is that, although a muscle cannot do work without producing heat, it can continue to produce heat without actively contracting, without doing work. In this latter state it is said to be in a condition of tonus or tone. No doubt when sufficiently analyzed tonus is discovered to be a state of imperceptible or incipient contraction. When a muscle having shortened continues to support a weight but shortens no more, it continues to produce heat although in the sense of the physicists it is not doing any external work: thus dynamogenesis and thermogenesis are separate capabilities. But further, the two related capacities of muscle for heat and work production only vary *pari passu* within certain limits. As a muscle lifts heavier and heavier weights it sets free more and more heat each time, and also if it raises the same weight each time, but under the influence of increasingly strong stimuli, it will evolve more and more heat each time. In this latter case the dynamogenic effects are the same throughout the series, while the thermogenic effects are greater and greater. As fatigue comes on, the heat-producing faculty is impaired long before the work-producing. Thus very tired muscles may be able to lift the load to the height to which they raised it when fresh, but they now do so with the greatest possible economy as regards their store of potential energy, for they evolve the minimal quantity of heat. They oxidize material to as slight a degree as possible. Muscular work and heat are thus not quantitatively parallel products: there is nothing comparable with this in a machine of human construction.

As regards the kinds of food from which we derive heat, our ideas have undergone changes since the time when the great chemist Liebig divided foods into flesh formers and heat givers; the "meaty" stuffs and cheese he placed in the former group, the starches, sugars and fats in the latter. After having been much criticised, this classification by Liebig is admitted to be substantially correct. While sugars and fats do not build up tissue, but are found to be normally oxidized more or less directly for heat giving or work producing purposes, the proteins (flesh formers) both repair tissue waste (by their nitrogen-containing moiety), and also contribute to heat production by the non-nitrogen-containing substances into which in digestion they are split up. Liebig told the truth but not the whole truth.

If during a certain time a person's temperature remains constant, that person is losing as much heat as he is producing. In technical language, thermogenesis, or heat production, is just balanced by thermolysis, or heat loss. Obviously, since we are constantly producing heat, unless we were as constantly to lose it, we should have to get hotter and hotter, and would damage our tissues by fatal fever. Now, it is very well known that the temperature of a healthy man (98.6 deg. F., 37 deg. C.) hardly differs by a degree from one year's end to the other, or from the poles to the equator. If no heat were lost at all, our temperature would rise 1 deg. C. in half an hour; in thirty-six hours our body fluids would be boiling; in another thirty-six, autocremation would be far advanced.

We may now ask ourselves the question, how it comes about that some animals have and others have not the power to keep their body temperature constant. Does not a fall of temperature necessarily depress vitality, and a rise, within limits, exalt it? The answer is that protoplasm *quâ* protoplasm is certainly depressed by a fall and stimulated by a rise of temperature, as can be well seen by the slowing effect of chilling an isolated frog-heart and the accelerating effect of warming it. It would seem then that there ought to be no such things as animals of constant temperature (warm-blooded). The solution to the puzzle is the high development of the nervous system in animals known as homoiothermic. In a mammal when the temperature falls, the first result is loss of heat from the skin and an incipient depression of the temperature, but, through the nerves of the skin, impulses are sent into the nervous system which emerge as reflex stimuli to cause contraction of the skin vessels and increased heat production in the muscles. The constriction of the skin vessels shuts some blood out of the skin and so diminishes heat loss, while the increased tone of the muscles increases heat production, and thus the loss of heat due to the fall of temperature is so rapidly compensated for that the temperature does not finally fall. Shivering is the familiar reflex effort on the part of the muscles to increase their heat as a result of the superficial heat loss.

This power of balancing thermogenesis against thermolysis we call thermotaxis; the homoiothermic animals have, while the poikilothermic animals have not, the power of thermotaxis. Now fever (pyrexia) is the upsetting of thermotaxis, the disturbance of this beautiful thermic balance. Theoretically, fever, or a rise of temperature, may occur if the heat production is too rapid for the heat loss, or on the other hand the heat production being unaltered, if the heat loss is diminished in rate. Both these states of the upset thermal balance occur. Dr. Hale White, the London physiologist, has shown that whereas in pneumonia and erysipelas the fever is due to increased thermogenesis, in typhoid fever and in suppuration the rise of temperature is due to a diminution in the thermolysis. Fever is to-day regarded by physicians in a totally different light from what it was even a few years ago—in itself a wholly bad thing to be reduced at any cost. The increased heat production is looked on as a reaction on the part of the living cells to the noxious stimulus of the micro-organism or its soluble poison, a response of a protective nature rather than of any other kind. Hence the indiscriminate lowering of the temperature by drugs (antipyretics) is not now nearly so common as it used to be. It is recognized as possible that the increase of heat (fever) may be evidence of sufficient vitality on the part of the living protoplasm to withstand the assaults of the infective agents, the increased heat being the bio-physical response to the microorganic insults. The drugs which benefit fever most are now regarded as doing so, not because they lower the temperature, but because they attack the specific cause of the malady; quinine, for instance, in malaria destroying the parasitic plasmodium malariæ, the salicylates antagonizing the materies morbi of rheumatic fever. Those versed in vegetable physiology have been able to show that even in the case of parasites attacking trees there is a rise of temperature as a reaction to these assaults; and therefore botanists actually speak of "fever" in plants.

Of course it is not to be imagined that under no circumstances is fever, or very hot blood, injurious to the body. Within the last few years definite experiments have been made showing that blood hotter than a certain temperature does permanently damage the cells of the central nervous system. A short exposure to 47 deg. C. (116.6 deg. F.), or a longer one to 42 deg. C. (107.6 deg. F.), killed the cells of an animal's brain by coagulating one of the essential constituents of their living substance. "Sunstroke," as it is called, is the result of the too hot blood injuring the cells of the brain, and especially those related to consciousness. When the cells are only slightly injured the person may recover, and be "a little queer in the head" for the rest of his life; if, however, the cells are decidedly over-heated, as in "heat-stroke" or "heat-apoplexy," death in collapse supervenes, the person never regaining consciousness. Heat-stroke of this kind may occur in places to which the sun never gains access, as, for instance, in front of the furnaces of a steamer in the Red Sea. On the other hand, depression of the temperature of the blood below its normal is as fatal, although not so rapidly, and for quite other reasons. Great loss of heat depresses the tissues so that death results. What is known to coroners' juries as "death from exposure" is really death due to heat-loss. An underfed, poorly clothed, and perhaps also alcohol-intoxicated person falls asleep out-of-doors on a frosty night; so much heat is lost that the heart and nervous system never recover: the person never wakes. The lowest (subnormal) temperatures in man have been recorded under these conditions (about 80 deg. F.)

The fact of the constancy of the temperature of the blood was recognized in the graduating of the thermometer. Very early in the evolution of that simple but indispensable instrument, an upper and a lower fixed point had to be agreed on. The lower point was virtually fixed in 1665 when Hooke advised that the temperature of water in the act of freezing should be accepted as the zero. Halley, the astronomer, was one of the first to assert that the temperature of boiling water was always the same, and thus a second fixed point was got. It is believed that the suggestion that the temperature of the blood or "blood-heat" might be a convenient fixed point was made by no less a man than Sir Isaac Newton in 1701. The temperature of the armpit of a healthy man, Newton proposed to call twelve degrees, the temperature of freezing water being zero. Fahrenheit in 1714 adopted this suggestion and took the body temperature as a fixed point, but his scale had 180 deg. in it, for it ranged from —90 deg. (temperature of a mixture of ice and salt) to +90 deg., which was blood-heat. Acting on the suggestion of the Danish astronomer Roemer, Fahrenheit call his zero (which he thought absolute zero) 0 deg., and blood-heat 24 deg., a duodecimal not a decimal scale. Later he became dissatisfied with the largeness of the degrees, and therefore subdivided each into four: twenty-four thus became ninety-six, which accounts for a figure of this order standing for the temperature of the blood, a fact which very few people could satisfactorily explain.—Knowledge.

A patent was recently granted for a method of employing the electric furnace in connection with the Bessemer converter or the open-hearth furnace in the manufacture of steel. For the initial treatment of the pig metal an acid-lined open-hearth furnace or a Bessemer converter is employed. The metal is thus desiliconized and in part decarbonized, from 0.04 to 0.30 per cent carbon being left, to prevent an oxidized condition and permit of more readily maintaining a fluid condition. It is then introduced into a mixer, preferably basic lined. On its way to the mixer it passes through a spout provided with a skimmer and the floating acid slag is removed to prevent damage to the basic lining of the mixer. In this mixer a basic slag aids in dephosphorizing the metal or neutralizing the acid slag which may be mixed with it. From the mixer from time to time charges are withdrawn and introduced into basic-lined electric furnaces, wherein the metal is treated with additions of oxide of iron, together with burnt lime or limestone to dephosphorize and desulphurize it. In the electric furnace silicon, manganese, vanadium, nickel, or other elements required to modify the character of the resulting steel may be introduced.

In the J. Gasbeleucht, W. von Oechelhaeuser describes a new balloon gas. Experiments carried out at the Dessau gas works on the preparation of a light gas suitable for filling balloons, by passing purified lighting-gas through highly heated retorts packed with charcoal or coke, showed that a suitable lighting-gas for this process could be obtained equally well either from the old horizontal retorts, or from the newer vertical ones. With precautions to prevent leakage through the retort walls, an increase in volume of 20 per cent was obtained. The process can be carried out either in vertical retorts or in horizontal retorts. With the latter, only those retorts which can be heated to 1,200 deg. C. can be used. The gas is drawn from the retorts at a very slightly reduced pressure and is passed through an air cooler, a dust filter to remove the carbon which separates out, and through an oxide purifier, and is delivered into a holder from which the balloon can be rapidly filled when required. The gas does not change in composition if kept in the holder. The average composition of the lighting-gas used and of the balloon-gas obtained was as follows:

	Lighting gas.	Balloon gas.
Heavy hydrocarbons	2.6	..
Carbon dioxide	1.3	..
Oxygen	0.2	..
Nitrogen	6.3	5.1
Carbon monoxide	5.3	7.3
Methane	24.7	6.9
Hydrogen	59.6	80.7
Specific gravity (air = 1)	0.41	0.225-0.30

The cost of transforming the lighting-gas into balloon-gas is about 3 pfennig per cubic meter (10d. per 1,000 cubic feet), or about equal to the cost of distribution of the lighting-gas, so that the balloon-gas can be sold at the gas works at the same price as lighting-gas to the consumer.

THE PRACTICE AND THEORY OF AVIATION.—II.*

THE LEADING AEROPLANES.

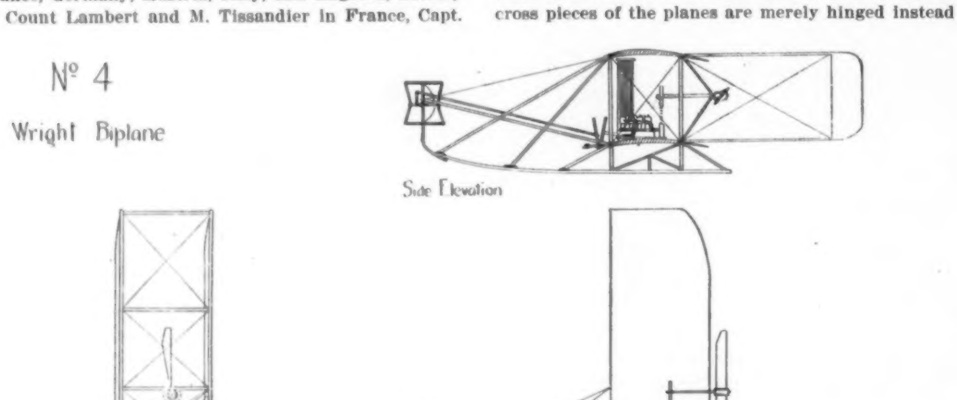
BY GROVER CLEVELAND LOENING, A.M.

Continued from Supplement No. 1816, Page 262.

4. THE WRIGHT BIPLANE.

As early as 1903 after exhaustive experiments in gliding Wilbur and Orville Wright made flights in a motor-driven aeroplane differing little from their present well-known type. The first public flights of the Wrights were made in September, 1908, when Orville Wright, at Fort Meyer, and Wilbur Wright, at Le Mans, France, astonished the world with their consummate skill. On December 31st, 1908, the Michelin prize was won for the first time by Wilbur Wright, who on that day flew for 2 hours and 18 minutes. The Wright machine to-day holds no great record, but the flights of Wilbur Wright at New York in October, 1909, and those of Orville Wright at Fort Meyer in July, 1909, are unquestionably the most difficult as yet negotiated. Among the biplanes the Wright is almost twice as efficient in power consumption as any other type.

Many machines of the Wright type are being flown in France, Germany, Austria, Italy, and England, notably by Count Lambert and M. Tissandier in France, Capt. Englehardt in Germany, and Lieut. Calderera in Italy. In this country the Wright machine is widely used, notably by Messrs. Coffyn, La Chapelle, Hoxsey, Brookins, and Johnstone, as well as the Wrights themselves.



The Frame.—Clear spruce and ash are used throughout the frame, which is very solidly but very simply built. The cross wires are of steel and made to fit exactly. All exposed parts of the frame are painted with an aluminium mixture.

The Supporting Planes.—Two identical and superposed surfaces made of canvas stretched over and under wooden ribs, support the machine in the air. Their curvature is somewhat more regular and flatter than the usual one used, and the surfaces are 3 inches thick near the center. These planes are 6 feet apart, they have a spread of 41 feet, a depth of 6.56 feet, and an area of 538 square feet.

The Elevation Rudder.—In the Wright biplane, the elevation rudder is so constructed that when elevated it is automatically warped concavely on the under side, and when depressed curved in the opposite way. This materially adds to the rudder's force. It is double surfaced, 70 square feet in area and placed well out in front, being supported mainly on framework, of which the mounting skids form a part. This rudder is governed by a lever in the aviator's left hand. To rise, the aviator pulls the lever toward him. This motion, being transmitted to the rudder mechanism by a long wooden connecting rod, causes the rudder to be turned upward to the line of flight, and consequently the machine rises. To descend, the aviator pushes this lever away from him.

The Direction Rudder.—The direction rudder is placed in the rear, on the center line, and consists of two identical vertical surfaces of 23 square feet area. This rudder is governed by the lever in the aviator's right hand. To turn to the left the lever is pushed out, while to turn to the right it is pulled in. But this motion is very rarely used, since the side to side motion of this lever also controls the warping, and the two motions in this type are very intimately connected.

Transverse Control.—The famous warping device is used by the Wrights for the preservation of lateral balance, and for artificial inclination when making turns. The rear vertical panel of the main cell is divided into three sections. The central one is solidly braced and extends either side of the center to the second strut from each end. From these struts the rear horizontal cross pieces of the planes are merely hinged instead of being continued portions of the cross piece at the center, and the two end vertical panels on either end are not cross braced. These two rear end sections of the cell are therefore movable. The entire front of the machine, as well as the actual ribs inside the surfaces, however, are perfectly rigid, there being no helical torsion of the ribs themselves as commonly supposed. Cables connect these two sections of the planes together and lead to the lever in the aviator's right hand. The operation is as follows: If the machine suddenly dips down on the right end, for example, then the lever is moved to the left side. This action pulls down the rear right ends of the surfaces, and at the same time pulls up the rear left ends of the surfaces. This causes an increase of incident angle of the outer end of the plane on the side depressed, and a decrease of incident angle on the opposite side; the consequent increase of lift on the depressed side and decrease of lift on the raised side rights the machine at once. But throughout this process the entire front face of the cell, as well as the rear central section, have remained perfectly rigid in every sense.

For turning to the left for example, it is evident that if this same lever be moved in a circular arc, outward and to the left (very much as a trace of the desired turn) then not only will the surfaces be warped, so as to raise the right end, but also the direction rudder is set to give the desired change of direction, and the consequent action is prompt and very efficacious.

In actual practice the direction rudder and transverse control of the Wright machine are almost never worked separately.

Keels.—There are no fixed keels on the Wright biplane. A small pivoted vertical surface is placed in front to indicate any change in direction of the relative air current.

Propulsion.—A 25-28 horse-power 4-cylinder Wright motor drives by chains, in opposite directions, two two-bladed propellers. These propellers are made of wood, and are placed at the rear of the main cell, one on either side of the center. They rotate at 400 r. p. m., and are 8.5 feet in diameter and of 9-foot pitch.

Seats are provided for two, the outer one for the aviator. They are placed on the front edge of the lower plane to the side of the motor.

The Mounting is on skids only. When starting the machine is placed on a small truck and run over a rail on the ground.

The total weight is from 1,050 to 1,150 pounds; the speed is 40 miles per hour; 41 pounds are lifted per horse-power of the motor, and 2.05 pounds per square foot of surface. The aspect ratio is 6.25 to 1.

Alterations.—The dimensions of the United States Signal Corps' machine and that built by the Aerial Company of France differ in that the spread is reduced to 36 feet and the surface area to 490 square feet.

In the French Wright machines of Count Lambert and M. Tissandier, the aviator sits next to the motor. When instructing these two men at Pau in the winter of 1909, Mr. Wilbur Wright had fitted to the machine an extra lever (to control the elevation rudder) on the right side of the passenger who sat next to the motor. The position of the levers for the passenger was therefore the reverse of the usual one, the lever controlling the direction rudder and warping being at the left hand. Messrs. Tissandier and De Lambert having learned to operate the machine with this disposition have never changed it. But they in turn have become the instructors of many purchasers of Wright machines, and since their pupils occupy the outside seat, they are taught to control in the normal manner.

Recently, most of the Wright machines have had pneumatic-tired wheels fitted to the landing skids, and supported on a rectangular frame at the rear there has been fixed a horizontal surface about 30 square feet in area. When normal this plane acts as a stabilizing keel, but it can also be turned up or down to aid the elevation rudder in its action.

A new experimental machine has lately been built in which the front biplane elevation rudder is entirely done away with, the elevation of the machine being controlled by the rear horizontal surface alone. This aeroplane is smaller and faster, the spread being 39 feet, the depth 5.5 feet, and the area 410 square feet. A 30 horse-power motor is used. 37 pounds are lifted per horse-power, and 2.5 pounds per square foot of surface. The aspect ratio is 7.1 to 1.

The Wrights are also bringing out a fast racing machine.

References.—Aeronautics, v. 3, Nos. 3 and 4, v. 5, p. 170; Sci. American, v. 99, p. 140, 209; Aeronautical Jour., v. 12, p. 114; Zeit. für Luftschiff, v. 13, p. 6; Aerophile, v. 16, p. 470; v. 17, p. 488; Boll. Soc. Aer. Ital., v. 4, p. 410; v. 6, p. 288; Locomocion Aerea, v. 1, p. 78; La Tech. Moderne, No. 1, p. 5; Encyl. d'Av., v. 1, p. 19; Am. Machinist, v. 31 (2), p. 473; Century, v. 76, p. 641; Peyrey, F., "Les Hommes Oiseaux"; Bracke, A., "Const. de l'Aerop. Wright"; Vorreiter, A., "Motor Flugapparate"; Genie Civil, v. 55, p. 342; Zeit. Ver. Deut. Ing., v. 53, p. 1098.

5. THE VOISIN BIPLANE.

The Voisin brothers began their activity as constructors of aeroplanes as early as 1905, when they constructed gliders for both M. Archdeacon and M. Blériot. These gliders were successfully operated over water, being towed at high speed and lifted from the water surface by motor boats. In 1906 the Voisins built a motor machine to the design of a young sculptor, the late M. Delagrange, and subsequently after making a few changes in the design, built a machine for M. Henri Farman which was the first truly successful aeroplane in Europe. The design of this type since then has remained substantially the same, except for the addition of some vertical keels. This type is at present very extensively used abroad, over one hundred having been manufactured.

The Frame.—The frame is made of ash with steel joints and several parts of steel tubing. It consists essentially of a large box cell mounted on a central chassis, and attached to it at the rear a smaller box cell. The central chassis is really a unit in itself, and carries the wheel mounting, the motor, the seat, and at the front, the elevation rudder.

The Supporting Planes.—The main supporting planes are two in number, identical and directly superposed.

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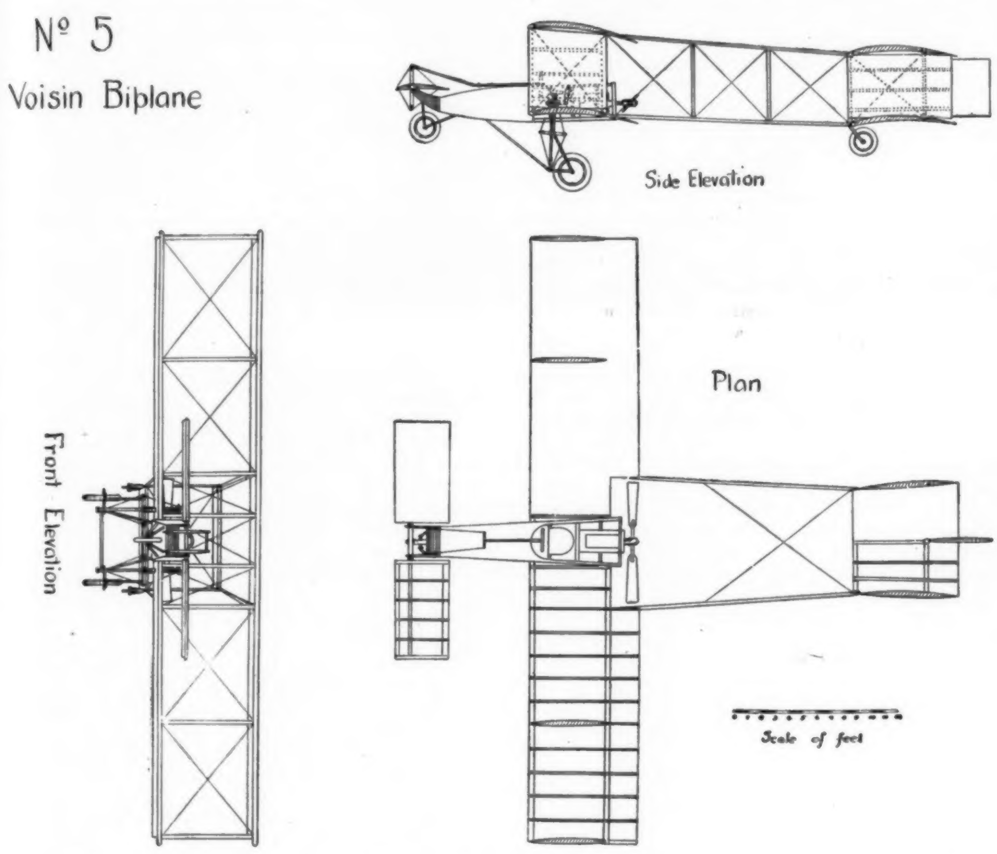
They are made of Continental cloth stretched over ash ribs. Their shape is rectangular. The spread is 37.8 feet, the depth 6.56 feet, and the area 496 square feet.

The Direction Rudder.—A single surface of 25 square feet area placed in the center of the rear cells is used for directing the machine. It is operated by a steering wheel and cables as on a boat.



The Elevation Rudder.—The elevation rudder consists of a single surface of 41 square feet area situated at the front end of the central chassis. It is governed by a lever system attached to the axis of the steering wheel. By pushing out on the steering wheel the rudder's inclination with the line of flight is reduced and the machine descends. By pulling in, the machine is caused to ascend.

Transverse Control.—There is no controlling apparatus for the lateral equilibrium in this type.

Keels.—The two horizontal surfaces of the rear cell about 130 square feet area act as keels to stabilize the machine longitudinally. For steadying the machine transversely and for keeping it to its course, there are provided six vertical surfaces (two vertical walls of the rear cell and four vertical partitions between the two main supporting planes).

Propulsion.—A 50-55 horse-power motor, placed on the rear of the central chassis, and of the main planes, drives direct a two-bladed metal propeller, 7.6 feet in diameter and 4.6 feet pitch, at 1,200 r. p. m. Several types of motors have been used.

The Seat is placed on the central chassis in front of the motor and just back of the front edge of the planes.

The Mounting is on two large wheels fitted with coiled spring shock absorbers at the front and two smaller wheels at the rear. To avoid any disastrous results if the machine should land too much "head on" a small wheel is fitted to the front end of the chassis directly under the elevation rudder.

The total weight is from 1,100 to 1,250 pounds; the speed is 35 miles per hour; 23 pounds are lifted per horse-power and 2.37 pounds per square foot of surface. The aspect ratio is 5.75 to 1.

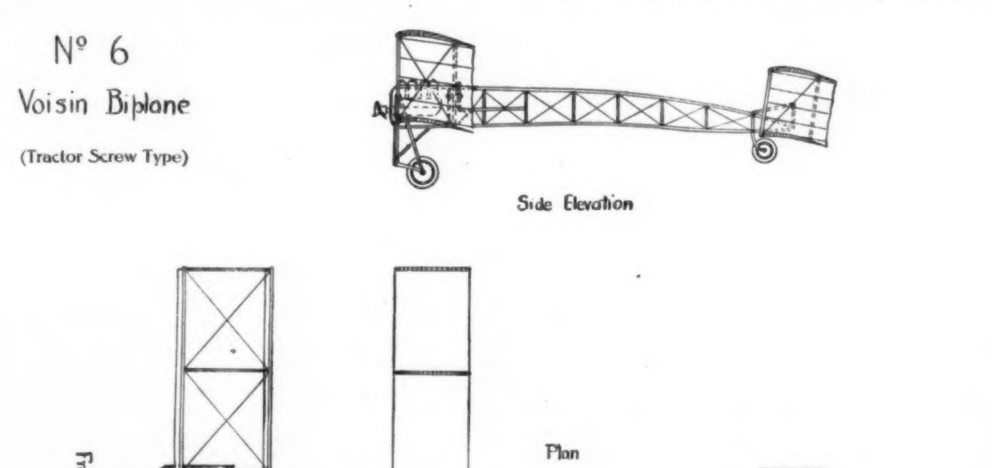
Recent Alterations.—The regular Voisin type has recently been changed, and is now equipped with a transverse control by ailerons, one placed at either side of the main cell. The vertical partitions have been entirely done away with, although otherwise the design remains the same. This machine has a spread of 36.1 feet, a depth of 6.56 feet, an area of 430 square feet, and a weight of 1,350 pounds. The motor used is a 60 horse-power 8-cylinder E. N. V. 22.5 pounds are carried per horse-power, and 3.14 pounds per square foot of surface. The aspect ratio is 5.5 to 1.

Besides this type a special racing type has recently been built and flown, notably by Bregi, Metrot, and Colliex. The chief characteristics of this machine are a great reduction in the number of struts, cross wires, etc., and the total elimination of vertical keels. The spread is 29.5 feet, the depth 5.75 feet, and the area 357 square feet. Ailerons are used, and a single plane horizontal keel is at the rear instead of two planes. The motor is the 60 horse-power E. N. V., and the total weight of the aeroplane is about 1,170 pounds. 19.5 pounds are lifted per horse-power and 3.27 pounds per square foot of surface. The aspect ratio is 5.13 to 1. In some of the newer Voisins the front elevation rudder has been eliminated.

References.—Aeronautical Jour., v. 12, No. 46; v. 13, p. 60; Aerophile, v. 15, p. 232; v. 16, p. 38; v. 17, p. 488; Aeronautics (Brit.), v. 1, pp. 11, 18; v. 2, p. 20; Sci. American, v. 97, p. 292; v. 98, p. 92; Locomocion Aerea, v. 1, p. 78; Boll. Soc. Aer. Ital., v. 6, p. 288; Flight, v. 1, pp. 19, 360, 485, 505; Ld. Tech. Moderne No. 1, p. 5; Soc. des Ing. Civ., v. 2 (1908), p. 13; Zeit. Ver. Deut. Ing., v. 52, p. 956; Vorreiter A, "Motor Flugapparate"; Encyl. d'Av., v. 1, p. 19; Genie Civil, v. 55, p. 341.

6. THE VOISIN BIPLANE (TRACTOR SCREW TYPE).

This machine, built by the Voisins and first experimented with in the late part of 1909, embodies several



totally new departures in the construction of biplanes, but has had little success, as yet. The Goupy and the Breguet, aeroplanes of this type, however, have been flown with great ease.

The Frame.—In this type the central chassis is extended far out to the rear. At the front are situated the motor and the propeller, and directly behind the propeller is the main cell. At the extreme rear is an auxiliary cell. Ash, steel joints and steel tubing are used throughout.

The Supporting Planes.—The two carrying planes, placed at the front on the central chassis, are identical and superposed directly. Their spread is 37 feet, the depth 5 feet, and the area 370 square feet.

The Direction Rudder and the Elevation Rudder.—The rear box cell is pivoted on a universal joint, and capable of being moved up and down or to either side. It consists of two horizontal surfaces about 80 square feet in area and two vertical surfaces 50 square feet in area. The vertical surfaces act as the direction rudder, when the cell is moved from side to side. The horizontal surfaces serve to control the elevation when the cell is moved up or down. The movement of the cell is controlled by cables leading to a large steering wheel in front of the aviator. To turn to the right, the cell is turned toward the right. To ascend, the inclination of the cell relative to the line of flight is decreased, the leverage desired being opposite in nature to that of a front elevation rudder.

Transverse Control.—There is no transverse control in this type.

Keels.—Four vertical partitions are placed between the two main planes, as in the other type of Voisin biplane.

Propulsion.—A 40 horse-power 4-cylinder Voisin motor placed at the front end of the chassis drives direct a two-bladed metal propeller of 7.2 feet diameter and 4 feet pitch at 1,300 r.p.m.

The Seat is situated on the central frame at the rear of the main cell.

The Mounting is on two large rubber-tired wheels in front, fitted with shock-absorbing springs and a single wheel at the rear.

The total weight is from 800 to 950 pounds; the speed is said to be 50 miles per hour; 19 pounds are lifted per horse-power, and 2.36 pounds carried per square foot of surface. The aspect ratio is 7.4 to 1.

References.—Aerophile, v. 17, pp. 441, 485; Aeronautics, v. 5, p. 200; Fachzeit, fur Flugtech., No. 39, Oct., 1909; Aero., v. 1, p. 347; Genie Civil. v. 55, p. 341.

(To be continued.)

C. A. Dawley, Jr., of New York has patented a two-cycle explosion engine. Air is compressed in the crank case to about 4 pounds per square inch pressure, and is used solely for scavenging. Gas and air are also compressed by an auxiliary cylinder and stored in a long valve chest, which acts as a receiver, at a pressure of 10 pounds. This pressure enables the full charge to be passed into the power cylinder at the moment when compression is about to begin. In the case of a gasoline engine the gasoline would be pumped to the inlet passage and sprayed into the cylinder by compressed air passing from the valve chest. An experimental engine, at Sibley College, Cornell University, having a bore of cylinder of 5 inches and a stroke of 6 inches, and weighing 1,050 pounds, developed 6 horse-power at 360 r.p.m. The average weight of single-cylinder 4-cycle engines rated at 6 horse-power is about 1,900 pounds, so that the saving is in weight and cost. There is no economy in operation over other engines.

TELEGRAPHY AND TELEPHONY.*

RECENT DEVELOPMENTS.

BY SIR JOHN GAVEY, C.B., M.INST.C.E.†

The subject selected by the President and Council for to-night's lecture covers such wide ground that to deal with it comprehensively would require a whole course of lectures rather than a single address. I hope, however, to be able to condense my subject-matter so as to give a general view of the most important and promising developments in each branch without exceeding the limits of your patience.

We may, I think, select the ordinary Morse circuit as our starting-point, as by far the largest proportion of the world's telegraphic traffic is still conducted on this system, and, as will be seen later, many of the developments in telegraphic apparatus have been based on the Morse method of signaling.

The Morse alphabet and its variants are so well known that it is not necessary to refer to them further than to illustrate the difference between the signaling on land lines and on cables respectively. In the former the signals are dots and dashes, while the signals transmitted over long cables are curves.

It is also unnecessary to dwell on the simple form of Morse circuit, which consists of a battery with one pole to earth, a key for making and breaking the contact between the battery and the line, and at the far end of the latter an electro-magnet which records all the movements of the key, further than to point out that the speed of working, even under the best conditions, is limited by the skill of the operator, and that it rarely exceeds thirty words a minute, the average being lower.

For many years this simple form of apparatus, or its equivalents, served the requirements of most countries; but as the telegraph service grew, and the traffic rendered it imperative to erect long lines directly connecting distant cities, the problem of obtaining a greater revenue from the large capital expenditure involved became pressing, and progress was made broadly on three distinct lines of development. In the first, means were designed for the transmission of several messages simultaneously over the same conductor; in the second, by the use of suitable mechanical and electrical devices, the actual speed of transmission was raised in overhead wires to ten or twelve times that possible by manual operating; and, finally, type-printing and writing systems were invented with varying degree of success.

Simultaneous Transmission.—The duplex system admits of the simultaneous transmission of two messages in opposite directions over the same wire without mutual interference. At each end of the circuit is a differential receiver which comprises two equally-balanced electro-magnetic coils, one of which is connected at its farther end to the line wire, and the other to an artificial line, which, in its electrical resistance and capacity, is as nearly as possible the equivalent of the actual line. The two inner ends of the magnet-coils are connected together, so that when a current is sent from the point of junction it divides equally between the actual and the artificial lines, and the coils being so wound that under these conditions the magnetic effect of one is neutralized by the magnetic effect of the other, the signals originating at either end pass through the home apparatus without affecting it. At the far end, however, it will be understood that when one station only is signaling the current passes through one coil alone of the receiving apparatus, and the signal is recorded. When, however, both keys are depressed simultaneously, if the batteries are so connected that they aid each other (they may either oppose or aid), then it will be understood that the current which circulates through the line wire and through both of the magnet-coils connected thereto is doubled; but as the current which circulates through the magnet-coils at each station connected to the respective artificial lines is unaltered, a signal is recorded, because the balance at either end is destroyed by the action of the other operator.

The transition from duplex to quadruplex working, viz., the sending of four messages simultaneously over one wire, involved but a step. There are two kinds of electro-magnets in use telegraphically—one provided with a simple soft-iron armature, which is equally attracted by positive or negative currents, and one provided with an armature which is itself a magnet, and which remains unaffected, or, rather, is repelled against its limiting stop, by a current that induces in the magnet coils a similar polarity to its own, but is attracted by a reverse current, which induces an opposite polarity. Either type of magnet may be used for duplex, but both types are used for quadruplex. The non-polarized magnet responds to a current of considerable strength in either direction, the polarized magnet to a weaker current in one direction only. In practice a single-current key is connected to a powerful battery, which is intended to work the non-polarized magnet; but the connections are led through a reversing key, which latter is designed to actuate the polarized magnet. When the single-current key is depressed the powerful current that circulates through the apparatus actuates the non-polarized relay at the far end, leaving the polarized relay unmoved. When the reversing-key alone is depressed, a weak current circulates, which actuates the polarized magnet, but is too weak to act on the non-polarized instrument. If both are depressed simultaneously, the powerful current from the single-current key is reversed by the depression of the double-current key, and both instruments at the far end are affected. The receiving apparatus at each end is arranged differentially, as in the duplex system, so that the outgoing currents have no effect on either of the receivers at the home end. This arrangement admits of four operators sending four messages simultaneously over one wire. Time does not admit of pursuing this interesting subject further than by stating that the artificial lines must be as far as possible the electrical equivalents in resistance and electrostatic capacity of the actual lines, and that means have to be provided for varying these factors, as the actual line itself varies under the influence of weather changes.

Another method, based on entirely different principles, which in theory admits of sending as many as twelve simultaneous messages in one direction, or double that number if duplexed, depends on the superposition of musical vibrations on a telegraphic circuit at one end of a line. To effect this result a number of electrically-driven tuning-forks, arranged to vibrate at different frequencies, are connected through telegraphic keys to a line wire, so that on depressing any one key a series of electrical vibrations, of the frequency of its companion tuning-fork, are sent through the line. At the far end the receivers are of a type that will respond to musical vibrations only, and each receiver is constructed or adjusted to respond to the vibrations of one of the distant tuning-forks alone, and to no others. If any one key is depressed, a simple musical oscillation traverses the line, and the receiver in tune responds. If two or more keys, however, are depressed simultaneously, a series of compound curves is transmitted, and those receivers that are in tune with the various components of the curves respond, and all the others remain unaffected. This system originated in America; but it has been developed and improved by Mercardier, in France, where it is said to have given good results recently. In the modern apparatus the receivers consist of so-called mono-telephones, each of which is so made and adjusted as to respond to only one frequency, not to any of the others.

A method of multiplex telegraphy based on entirely different principles is the following: The working of the Mercardier system just described has shown that the electrical conditions of an overhead line admit of a far more rapid transmission of readable signals than is possible by ordinary manual operation, and it has also shown that the continuous currents used in general for signaling dots and dashes may be replaced by intermittent currents which, by suitable means, can be translated at the receiving instruments into the ordinary Morse dots and dashes. This line of reasoning led to the following development: A large number of insulated metallic segments are arranged in a circle at each end of the line, and divided into groups, say, of eight each. No. 1 of the first group is metallically connected with No. 1 of all the other groups, and, through the transmitting-key, with No. 1 instrument, No. 2 with No. 2 series of contacts and instruments, and so on. Centrally-pivoted arms, provided with metallic brushes which ride over the segments, are joined one to each extremity of the line wire, and it is obvious that if both these arms, starting simultaneously from No. 1, revolve at precisely the same speed, then each segment, with its instrument at one end, is for a brief period placed in connection with the corresponding segment with its instrument at the distant end. If the sending-key of No. 1 instrument is depressed, a brief current is transmitted to its corresponding instrument when the revolving arm reaches No. 1 contact of any group, to be repeated when the arm reaches No. 1 of the next group, and so on throughout the series. Instead, therefore, of a dot being represented by a single current of continuous duration, it is replaced by three or four shorter impulses spread over the same period of time, and a dash by three times the number of impulses. By this means it is possible, under favorable conditions, to transmit eight messages simultaneously over one wire. This system, invented by Delaney, was developed to some extent in this country, but owing to various causes it has recently been abandoned. It is, however, referred to here as the principle of revolving commutators in use in other forms of apparatus to be dealt with later. The second method of increasing the output of telegraphic wires is the automatic or machine-transmitting instrument, which is typified by the Wheatstone apparatus, adopted and perfected by the Post Office in Great Britain. In all instruments of this character a long paper ribbon is perforated by a suitable machine in an arbitrary manner, and the transmitting and receiving apparatus is so designed as to transcribe these perforations, at the distant end, into Morse signals, into similar perforations, into type-printed messages, or even into written characters.

In connection with the perforated tape, or slip, as it is termed, used in the Wheatstone system, there are employed three rows of perforations. The center row is continuous, as it is used for drawing the slip through the transmitter at the speed at which the latter is running; the upper and lower holes cause the transmitting-key to send electrical signals—dots when these rows are vertical, dashes when diagonal. The actual apparatus which effects this object is comparatively simple. Two small vertical plungers, to which an up-and-down motion is imparted by the clockwork of the apparatus, are pivoted to two bent levers connected by horizontal rods with a small vertical transmitting-key, which, in one position sends a positive, and, in the other a negative, current to line. When no slip is in the machine, the plungers as they rise and fall move the key to and fro and send reversals, which are received as dots at the far end. When the slip is inserted, if the plungers meet a series of vertical perforations they pass through at each movement, and dots are still transmitted; but if they meet diagonal perforations, the movements of the plungers are arrested by the unperforated portion of the paper slip, and the transmitting-key is not drawn back until one of the plungers enters the lower diagonal hole of the slip, and withdraws the key from its sending position, thus recording a dash.

This Wheatstone system has been very fully developed in the United Kingdom. It is capable of dealing with traffic at a maximum rate of 540 words per minute, and it is invaluable for the transmission of news. Thus, in the central office in London, items of news may have to be transmitted to fifty or more towns simultaneously. Circuits are made up for news transmission, each providing for a number of towns, some of the circuits being of a permanent character, and some formed temporarily to meet special requirements. As many as eight Wheatstone slips can be punched simultaneously in one operation, and each length of slip is run through the necessary transmitters at the highest speed considered judicious. When long press messages are received, they are divided into sections, and each section handed to a separate telegraphist for perforating, so that the transmitting apparatus can be worked at its maximum capacity. Without this useful and adaptable apparatus, it would be almost impossible to deal satisfactorily with the vast amount of news traffic which is sent daily to every town in the country.

For ordinary public message traffic, on lines of moderate length, where each individual message is short, the Wheatstone has certain disadvantages—namely, the initial delay in perforating the slip, its distribution, and, finally, the redistribution of the received slip among the writing telegraphists; for it is obvious that, at the high speed at which Wheatstone is worked, several operators are required at each end of the line to keep pace with the apparatus. In practice in this country, for circuits of moderate length it is generally considered preferable to provide direct Morse apparatus, worked simplex, duplex, or quadruplex, as circumstances may dictate.

With overhead lines the limit of speed in automatic working is that imposed by the receiving apparatus, which, owing to its self-induction, a factor referred to later, obstructs the reception of Morse signals at a higher speed than that named. This difficulty has been overcome by substituting a chemical for an electro-magnet receiver. In this form the current at the received end passes through a long paper ribbon saturated with a solution which is decomposed by a positive current. The Morse signals appear in blue lines on the received slip.

It is said that with this method a maximum speed of 1,000 to 1,200 words is possible under favorable conditions; but the difficulty in working at such high

* English Mechanic and World of Science.

† The "James Forrest" lecture, delivered before the Institution of Civil Engineers, June 22nd, 1910.

speeds, where characters are received in Morse code, and have to be transcribed manually, is the division and distribution of the slips among the large number of writers necessary to keep abreast of the work, the precautions needed to avoid loss of messages, the injurious effect of brief contacts, caused by workmen, resulting in the loss of several words, and last, but not least, the difficulty and delay in obtaining repetitions where errors, false signals, or missing words render this necessary.

All the foregoing methods increase the carrying capacity of the wires; in other words, they reduce the capital expenditure per message; but none of these increase the output per operator, nor do they diminish the working cost in the instrument room; in fact, with high-speed automatic transmission this cost may be higher than with other methods described. The messages have to be prepared by the perforation of the punched slip, telegraphists have to control the sending and receiving apparatus, and the Morse slips, as they are reeled off the receiving apparatus have to be divided and distributed among a number of operators for transcription. The initial preparation of the transmitting slip will always, of course, be necessary in all automatic systems; but inventors have turned their attention to increasing the speed and reducing the cost of transcription at the received end, in the case of manual as well as automatic sending, by the substitution of typing apparatus, worked mechanically or electrically, for the manual transcription. A very considerable number of instruments have been designed to achieve this end; but one of the earliest which has met with permanent success, and by means of which a very large proportion of the work in Europe, and nearly the whole of the transcontinental work is dealt with, is the well-known Hughes type-printing instrument.

Each instrument comprises a type-wheel, which consists of a disk, on the periphery of which are embossed the letters of the alphabet, numbers, and other signals that have to be transmitted; a piano-like keyboard, on the keys of which are engraved the letters and signals which appear on the type-wheel; and a horizontal plate with a series of slots arranged in a circle. Inclosed in each of these slots, and connected with one of the sending-keys, is a movable plunger, which is raised when the key is depressed, but which normally lies flush with the surface of the plate. An arm, carried on a vertical shaft in the center of the plate, is made to revolve above it by the motive power which drives the instrument, and when a key is depressed, this arm is arrested momentarily by the protruding plunger, and a current is sent to the distant station. The printing-disk and the revolving arms at both sending and receiving stations move in unison, and this is effected mainly by the action of a governor, and any slight want of coincidence is corrected mechanically each time a letter is printed. Below the type-wheels are long paper ribbons, and it will be understood that both instruments starting from zero, and running uniformly, as a key is depressed, and the plunger corresponding with the letter to be signaled is raised, the electrical current is sent to line at the moment that the letter to be printed is immediately over the paper; and if the latter is raised momentarily, that letter is printed.

The Hughes method of transmission has many advantages. It provides a clearly-typed message for delivery instead of a written one; it removes a possible source of error in transcription; and it increases the speed of working, as compared with Morse, by about 25 per cent. It can be duplexed, and it is used by the Post Office on all its Continental wires. It has, however, the disadvantage that a considerable interval of time elapses between the transmission of two consecutive signals, owing to the revolving arm having to traverse all the intervening letters. Baudot has obviated this waste of time by adopting the multiple system of telegraphy. He entirely abandons the Hughes method of transmission, and forms an arbitrary signal-code which, by means of five consecutive currents, some plus, some minus, in combination, he represents each letter of the alphabet, figures, or other signals. By this method he can provide four to six channels simultaneously on one wire, each being worked manually. In the quadruple system, that most generally in vogue, he uses four separate keyboards, each containing five keys. Either key, when in its normal condition, is in a position to send a negative current, and when depressed a positive current, to line. Each of the five keys of one keyboard is connected to five separate and contiguous metallic contacts arranged in a circle. An inner continuous circle is connected to the line wire. A revolving arm, moving at a uniform speed, connects in regular sequence the individual key sections with the continuous line circle, and during each revolution it transmits through the line the group of signals formed on each keyboard. At the receiving end a corresponding arrangement, the arm moving at the same speed, connects the line in regular sequence with the four receiving instruments, each set being provided with five polarized relays working five electro-magnets. During each revolution of the arms at the sending and receiving ends the electro-magnets repeat the positions of the transmitting keys, the armatures of those receiving positive currents being raised, and those receiving negative currents depressed, and it remains only to translate these arbitrary code-signals into printed letters. This is effected in the following very ingenious manner: At each receiving instrument two disks, firmly fastened together, have on their peripheries a series of serrations, corresponding with the arbitrary code, which, in certain defined positions, represent the various letters of the alphabet. Riding on the periphery of one of them are five levers, termed selectors, each of these levers being so pivoted as to be susceptible of a slight to-and-fro movement on its axle, and also of a transverse movement in the line of the axle. When all the electro-magnets have their armatures raised the selectors rest on the inner disk; but if a certain number of the armatures are depressed, then, through the action of intermediate levers, the corresponding selectors are shifted to the second disk. As the two disks revolve together the combined selectors at some point drop simultaneously, and for a brief interval, into the series of serrations which correspond with the letter code signaled from the far end, and this movement and the rapid jerk out of the serrations as the disks revolve causes the letter to be printed from a type-wheel which revolves at the same speed as the disks. The uniform revolution of the contact-arms, the coded disks, and the type-wheels are maintained by a clever adaptation of governors and brakes, partly electrical, partly mechanical, which time does not permit of further consideration; provision is likewise made for the lag of the current in transmission over the line.

The Baudot system admits of the transmission of a much larger number of messages over each wire than the Hughes. It is also more flexible, inasmuch as the various channels it provides can be divided among an equal number of towns; thus Paris can use two channels to Lyons and two to Marseilles over a Paris-Lyons circuit extended from Marseilles, and so on. It is largely used in France, and has been introduced into this country.

It will have been observed from the foregoing description of typical forms of apparatus that there are three distinct methods of telegraphic transmission, with which we are mainly concerned to-night, although others might be mentioned. In the first, an arbitrary code of signals is repeated in similar arbitrary signals, by which the alphabet is artificially represented and the message is read by a skilled operator; in the second, what may be termed the dial type of apparatus is used, where two type-wheels, either moved mechanically or electrically, revolve isochronously, and they may either show fleeting letters or print them in permanent characters; and in the third, an arbitrary set of electrical signals is devised which actuates specially-designed apparatus which may reproduce the message in legible characters, printed or even written. The third method has been utilized by various inventors and applied to automatic transmission, so as to dispense with manual transcription at the receiving station.

In all cases a paper ribbon or slip is perforated by punches, generally actuated by a specially-designed typewriter keyboard, in which the depression of any key causes a series of perforators, representing the arbitrary combination of the corresponding letter, to appear on the slip. This is passed through an automatic transmitter, the electrical currents corresponding with the perforators are transmitted over the circuit, and the distant apparatus actuated.

Murray has devised a system which has undergone lengthy trials, both at home and abroad. His slip has one row of perforations which gears into the moving mechanism of the transmitter, and below this a second series of perforations which represent his artificial signaling code, which is of the Baudot type. The transmitting and receiving apparatus must run isochronously, and this is provided for by an ingenious method, which time does not admit of explaining in detail.

When the vertical plunger passes through a perforator a positive current is sent over the circuit, and when the plunger is stopped by the paper a negative current circulates. The result at the receiving apparatus is that an exact counterpart of the transmitted slip with its perforations is reproduced, and this perforated slip is passed through and actuates an automatic typewriter, which prints the message. The typing machine is fitted with five horizontal plungers, which are prolongations of an equal number of slotted combs, to which in action a to-and-fro motion is imparted. The perforated slip acts on the principle of the Jacquard loom, and when at a given moment a series of perforations appear, the corresponding plungers move forward, and the remainder are arrested by the unperforated part of the paper. The slotted combs are at the moment so grouped that the one letter indicated by the code is actuated by the controlling motive power, and it is accordingly printed, and the combs restored to their normal position ready for the next letter. The message is typed in page form. An improved printer has recently been devised by Mr. Murray.

Creed has worked in the same direction; but he uses the ordinary Wheatstone alphabet already described, and, of course, the Wheatstone transmitter. At the receiving end a perforated Wheatstone slip is reproduced by a punching-machine, which, controlled by the reverse currents from the transmitter, and using compressed air as a motive-power, perforates the received slip at considerable speed. This slip is then passed through an automatic typewriter adapted to work with the Wheatstone alphabet, which types the message on a long slip, to be gummed on the telegraph form. In both these cases the received slip can be inserted in a second automatic transmitter, and the message sent on to another town—an advantage in the transmission of news, which frequently has to be redistributed from large provincial centers to other towns having no direct communication with London. Both these systems are in use in the British Post Office.

Siemens and Halske, in Berlin, have devised an automatic system in which, by means of suitable apparatus, the message is printed by the receiving apparatus direct by photographic methods.

You have already had described to you the character of the prepared slip which is used for transmission. Time precludes even a reference to the ingenious details of the apparatus employed beyond stating that the final typed characters are produced photographically by an electric spark, which momentarily illuminates the required letter. The alphabet is stenciled on a revolving disk, and the arrangements are such that the electric spark passes only when the letter corresponding with the arbitrary signal is in the right position for printing.

The Western Union Telegraph Company in America, the land of long-distance circuits, has introduced extensively a system known as the Barclay automatic type-printing apparatus. At the sending end, the code of electrical signals adopted consists of long and short intervals, either marking or spacing, representing the various letters of the alphabet. Every letter is represented by six current alternations; but the receiving apparatus is so designed that although every current acts on an escape-wheel that makes a momentary contact with certain selecting relays, only those of long duration effect any movement in the latter. There are thirty-two printing magnets, which act as the keys of a typewriter, and cause the message to be printed direct on the receiving instrument.

It may be added that, although any one of the systems described or referred to can be made to do excellent work, the actual selection of the apparatus best calculated to meet the requirements of any country depends entirely on local conditions, length of the lines, character of the work to be dealt with, idiosyncrasies of the staff, etc., and that it would be eminently unwise to dogmatize on the subject. To what extent uniformity of practice is likely to arise in the future is a doubtful question, as each country is likely to progress on the lines which have been firmly established as the best adapted to its wants. In this respect, telegraphy may be said to occupy a somewhat unique position from the inventor's point of view, there being no tendency at present in the direction of adopting one particular type of apparatus as being best adapted for all purposes.

Writing telegraphs, based on the fact that two ordinates at right angles to one another can be made to describe any curve, have been designed. The telewriter, in which the pen is connected to two arms which follow the movements of the writer, and, in doing so, pass over varying resistances, and transmit to line currents of varying strength, is well known. At the receiving end, two pivoted electro-magnets, placed in a very powerful magnetic field, are deflected over arcs dependent on the strength of the current circulating at any moment. Two arms at right angles to one another are connected to the transcribing pen, one arm being pivoted to each magnet, and the writer's movements are reproduced.

There is only time to refer briefly to the beautiful writing apparatus designed by Pollak and Virag. In this, a slip is perforated by suitable means with nine rows of holes of varying sizes, suitable flexible brushes make contact through these holes between batteries and the line wires, and thus cause currents of different electromotive forces and duration to circulate over the line, and to act on two telephone-receivers at right angles to one another. Rays of light are reflected from one to the other and on to a photographic slip, and the written messages, which can be transmitted at 600 to 1,000 words a minute, appear developed and fixed on the sensitized paper which emerges from the dark closet of the apparatus.

There are numerous type-printing instruments for the distribution of news, which, however, are so well known that further reference to them is unnecessary.

(To be continued.)

COSMICAL EVOLUTION.*

A NEW THEORY.

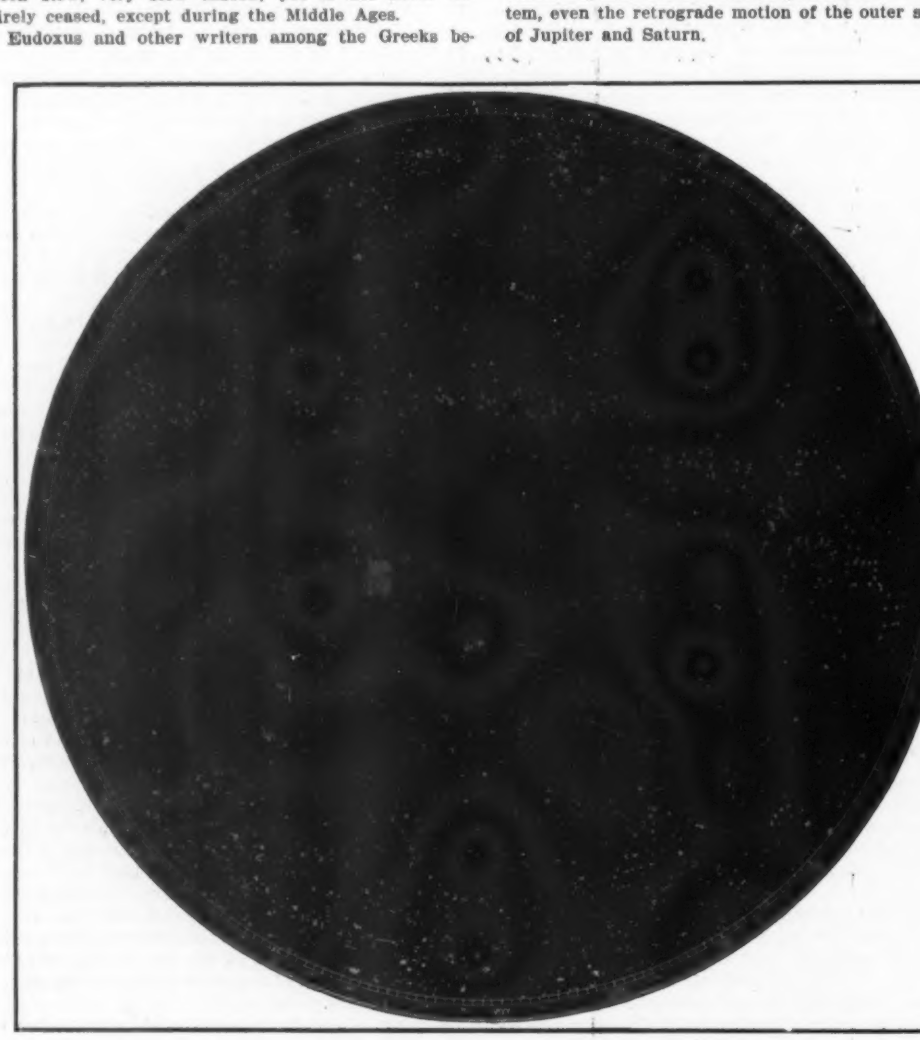
BY T. J. J. SEE.

IN the brief time available to-night I shall not attempt elaborate arguments respecting my recent investigations, many of which are of mathematical character and of considerable length, and are given in my new work, "Researches on the Evolution of the Stellar Systems," Vol. II., 1910; but shall content myself with a popular summary suitable for a general audience. In the first place, it should be remarked that although the New Cosmogony is the newest of the sciences, the Old Cosmogony dates back to the time of the Greek philosopher Parmenides, who was the revered teacher of Plato. On the whole, the progress of cosmogony throughout the centuries has been slow, very slow indeed; yet it has never entirely ceased, except during the Middle Ages.

Eudoxus and other writers among the Greeks believed that the heavenly bodies revolve in crystalline spheres, and had been set revolving in circles because the circle is a perfect geometrical figure, and was therefore preferred by the Deity for the orbits of the stars. After Kepler's discovery of 1609, that the planetary orbits are elliptical, it was necessary to modify these views to correspond to the true laws of nature. Both Kepler and Newton wondered at the roundness of the planetary orbits, but were unable to assign the cause of this remarkable law of our system. No physical cause for the circularity of the planetary orbits was assigned prior to 1796, but in that year Laplace explained this property of the planetary paths by supposing that the planets had been detached in the form of rings which afterward condensed into globular masses. A similar explanation of the circularity of the satellite orbits was also put forth at the same time, so that all these bodies were supposed to have been detached by a gently accelerated rotation.

The doctrine that the planets and satellites were thrown off by rotation has been current for more than a century, but it is now definitely proved to be erroneous, and has been quite abandoned by astronomers since the publication of my researches of the year 1908, showing that the roundness of the orbits is to be explained by the secular effects of a resisting medium, and by no other cause whatsoever. Laplace's theory is therefore finally overthrown, and what is known as the capture theory substituted in its place.

It is shown by accurate calculations based on Babinet's criterion that the planets never were any part of the sun, but were formed in the outer parts of the solar nebula, and have since neared the sun, and had their orbits rounded up and made smaller and smaller. The satellites, including the terrestrial moon, have likewise been captured and added on to the planets which now govern their motions. The result of the capture theory is essentially a new nebular hypothesis, which explains all the known phenomena of our system, even the retrograde motion of the outer satellites of Jupiter and Saturn.



ISOGRAPHIC PROJECTION OF THE SOUTHERN CELESTIAL HEMISPHERE.

The nebulæ are represented by dots, the clusters by crosses.

In the old nebular hypothesis it was supposed that a nebula is a fluid mass in equilibrium under conditions of hydrostatic pressure, so that the rotation of the central nucleus transmitted pressure outward and aided in throwing off a ring of nebulous matter from the periphery; in the new nebular hypothesis there is no fluid pressure from the center outward—the bodies develop as independent nuclei in the nebula, and drift toward the larger centers of attraction. Thus the planets are added on to the sun from without, and the satellites added to their several planets. When the planets began to develop in our primordial nebula they were at great distances from the sun, and hence nearly as far away as the comets are now.

Accordingly it is evident that our planets and comets were originally related. The comets which come to us from a great distance are the survivals from the outer shell of the primordial nebula—the matter of the inner part of the nebula having been eaten out to produce the sun and planetary system. This accords with the appearances of the other nebulæ, which are shown to be excessively rare and of vast extent. It has taken us three centuries to find out the real meaning of the comets; but the light now thrown on the connection between planets and comets is worth all the labor which has been bestowed upon this difficult subject.

The repulsion of the matter in the tails of comets from the sun is easily explained; for it is now shown that the nebulæ themselves are formed from fine dust expelled from the stars by the action of repulsive forces; and as the comets are survivals of our primordial nebula, the repulsion of the volatile elements in the tails of comets is not remarkable. This dust drifts about hither and thither, and finally collects into clouds called nebulæ. It is shown by astronomical photography that the whole background of the sky is more or less covered by a faint haze of nebulosity.

When this nebulosity collects into dense clouds we have nebulæ, and they begin to settle down and develop into cosmical systems. Accordingly it is now shown that the stars produce the dust which collects into nebulæ, and finally develops into stars. So that the stars form the nebulæ, and the nebulæ in turn form the stars; and the universe is governed by a cyclical process, apparently of endless duration. The result of this whole investigation is a greatly improved theory of the starry heavens.

One of the points of greatest interest attaches to the discovery that the congregation of the nebulæ away from the Milky Way, with maximum accumulation near the poles of the Galaxy, is the result of the action of repulsive forces, under which fine cosmical dust expelled from the stars is driven as far away from the Milky Way as possible.

Heretofore astronomers have had no general theory of the origin and distribution of the nebulæ. As long ago as 1785 Sir William Herschel noticed a tendency in these cloud-like masses to gather in the regions of the heavens away from the Milky Way, and this law was further confirmed by Sir John Herschel about 1845; but no explanation of the facts thus established has been forthcoming.

It is well known that I have been occupied with the study of Repulsive Forces about ten years, and have at length shown that the nebulæ are formed from dust expelled from the stars, which in turn are formed from the condensation of nebulæ. The tendency of the nebulæ to avoid the Milky Way is due to the expulsion of the nebula-forming dust from the stratum of stars constituting the Milky Way, and therefore the clouds produced by the condensation of this dust naturally accumulate in the regions remote from the Galaxy. As the nebulæ develop into stars surrounded by systems of planets, it seems probable that they are gradually drawn back into the starry stratum, by the attraction of the stars lying in the plane of the Milky Way. One of the greatest and most fundamental facts established by the telescopic explorations of the Herschels on the arrangement of the sidereal universe thus finds a natural and simple explanation in accordance with known laws.

It is thus clear that a complete theory of cosmical evolution involves the action of both attractive and repulsive forces, and should enable us to explain all classes of the heavenly bodies, namely, suns and stars, double stars, single stars surrounded by planetary systems, habitable planets revolving about the fixed stars in nearly circular orbits, and rotating on their axes like the planets of the solar system; comets, variable stars, new or temporary stars, and finally the development of multiple stars and clusters. Accordingly Laplace's original nebular hypothesis, implying the formation of bodies by the throwing off of rings, is incorrect and now quite abandoned by astronomers.

The most important physical cause at work to modify the motions of the heavenly bodies is the action of a resisting medium. The variable stars, especially the cluster variables, are due to planets revolving in such a medium and blazing up at the time of perihelion passage, and thus the periods are very regular. New stars are due to collision with large planets; hence the outbursts are of short duration.

The discoveries made during the last two years have enabled me to reduce cosmogony to a new basis, by which it now becomes an exact science. The development of a new science is always of profound interest. In this connection I will merely point out how remarkably every part of the new Nebular Hypothesis, or Capture Theory, supports every other part; so that the whole work is knit together into a harmonious whole of such irresistible strength that it cannot be overthrown. The craters on the moon show the size of the small bodies originally composing our nebula, for these craters are proved to be indentations due to the impact of satellites against the moon's face, and not volcanic action, as was long believed. The new theory explains the rotations of the planets on their axes, and their obliquities, as well as the motions

* Address to the Popular Educational Society of San Francisco, August 26th, 1910.

of the satellites and the roundness of their orbits. The comets, as already remarked, are the surviving fragments from the outer shell of the ancient nebula which formed our system, the matter of the inner parts having been eaten away in forming the sun and planets. Thus the planets and comets were originally related, and the relationship is further illustrated by the connection of the Asteroids with the short-period comets captured by Jupiter. It is shown by the researches of mathematicians that both of these classes of small bodies have been captured and thrown into their present positions by the disturbing action of this giant planet. A nebula might be not very inappropriately described as a cluster of comets so dense as to shine with a hazy light.

One other result of deep interest is the increased extent of our solar system, which is shown to be of vast dimensions. Neptune's orbit is so round that it cannot possibly be the outermost of our planets, and good reasons may be adduced for thinking that some of the unseen planets still revolving on the outer borders of our system may yet be discovered by observation, although the search will be difficult, owing to the great distance and faintness of the sun's light in these remote regions of space.

I will add just one more concluding announcement, namely, that the planets now shown to revolve about the fixed stars are inhabited by some kind of intelligent beings, so that life is unquestionably a general phenomenon of the universe. It is well known that the late Prof. Newcomb expressed similar views in an address delivered at the dedication of the Flower Observatory, Philadelphia, in 1897. The proof is now much more complete than ever before; and men of science will have to admit life to be general on the countless worlds revolving about the fixed stars, or else concede that life upon the earth is an accident and a mistake, existing for hundreds of millions of years in direct violation of the laws of nature, which no philosopher could possibly admit; for this would be a *reductio ad absurdum* more convincing than those developed in the science of geometry and taught in the best schools and universities of the world. The life flourishing on the earth and believed to exist also on Mars and Venus is but a drop in the Pacific Ocean compared to that flourishing on the thousands of billions of habitable worlds now definitely proved to revolve about the fixed stars.

METALLIC RADIUM.

The following note has been presented to the Académie des Sciences by Mme. P. Curie and M. A. Debièrne:

For the purpose of obtaining metallic radium we have employed the methods for the preparation of metallic barium which have been described by Guntz. A few preliminary experiments were made with barium, using a very small quantity of material (about 0.1 gramme, or 1.5 grains), a circumstance which made the operations very delicate. These experiments served to determine the method of operation employed for the preparation of metallic radium.

In principle, the method consists of the formation of an amalgam and the removal of the mercury by distillation in appropriate conditions. The amalgam was obtained by the electrolysis of a solution of absolutely pure radium chloride (atomic weight 226.5), using a cathode of mercury and an anode of platinum-iridium. The quantity of radium chloride was 0.106 gramme (1.635 grains), the quantity of mercury was about 10 grammes (154 grains). After electrolysis, the solution still contained 0.0085 gramme (0.131 grain) of the salt. The amalgam decomposes water and is rapidly acted on by air. It was entirely liquid, although barium amalgam produced by the same process contained numerous crystals. The radium amalgam was dried and quickly transferred to an iron cup, which had been kept in a reducing atmosphere of pure hydrogen. The cup was then placed in a tube of quartz, from which the air was immediately exhausted.

The distillation of the mercury is an extremely delicate operation. It must be accomplished without causing the slightest ebullition, which would expel some of the contents of the cup. We finally effected the distillation in pure hydrogen, at a pressure which always exceeded the pressure of the saturated vapor of mercury at the temperature of the cup. This temperature was indicated by a thermo-electric couple, one junction of which was inserted in the iron wall of the cup.

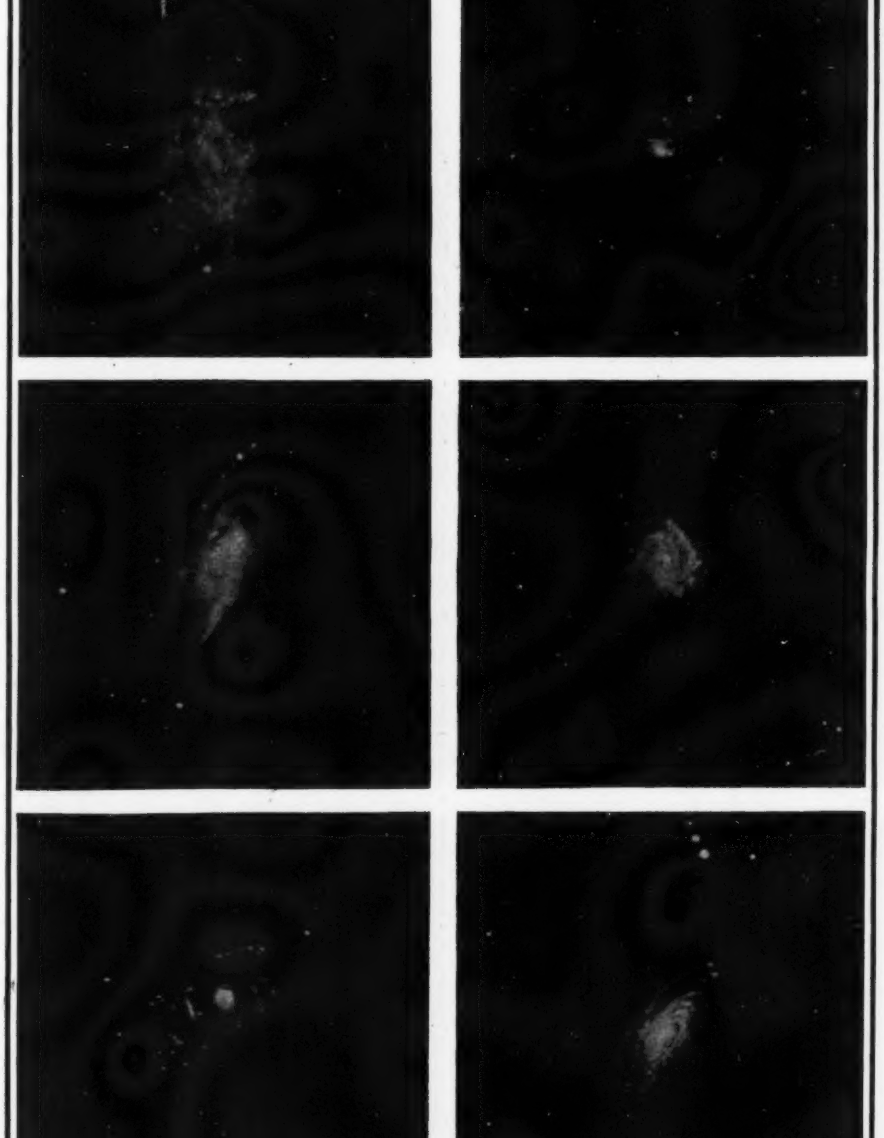
As we worked with so small a quantity of substance we required hydrogen of exceptional purity. We found that hydrogen purified and dried by ordinary methods attacked the amalgam and the metallic radium. In order to complete the purification, the hydrogen was admitted into the apparatus through a tube of platinum, which was heated to a high temperature in an electric furnace. This process of purification seems perfect.

The greater part of the mercury was distilled off at 270 deg. C. (518 deg. F.). The temperature and the pressure of the hydrogen in the apparatus was then increased progressively. In order to make it possible to observe the contents of the cup throughout the operation, the heating was effected by means of gas burners. The amalgam was solid at 400 deg. C. (752 deg. F.), but at a higher temperature it melted and gave off mercury vapor. The fusing point, which could be determined very exactly, rose gradually to 700 deg. C. (1,292 deg. F.). At this temperature no distillation of mercury, or condensation on the cold wall of the tube, could be observed, but the metallic radium began to volatilize rapidly and its vapor vigorously attacked the quartz tube. The operation was then stopped. The cup was found to contain a brilliant white metal, having a sharply defined fusing point near 700 deg. C. (1,292 deg. F.). We think that this metal was very nearly pure radium. It adhered strongly to the iron cup and could not be detached without difficulty.

Metallic radium alters very rapidly in the air, and instantly turns black, probably in consequence of the formation of a nitride. A few particles of the metal were detached with a small burin. One of them fell on a piece of white paper and produced a black spot which resembled the effect of scorching. The detached metal, put into water, decomposed the water rapidly and the greater part of the metal dissolved, a fact which would indicate that the oxide is soluble. The black residue was almost entirely dissolved by the addition of a very small quantity of hydrochloric acid. This residue would appear to be a nitride, formed during the exposure of the metal to the air. As the metal dissolves almost completely in dilute hydrochloric acid, it cannot contain an appreciable quantity of mercury.

The iron cup, with the metal that still adhered to it, was placed in a tube, which was sealed *in vacuo*, for the purpose of measuring the penetrating radiations emitted by the metal and ascertaining whether its radio-active properties are such as would be expected. The radio-active equilibrium has not yet been attained, but the preliminary measurements show that the radio-activity is increasing in close accordance with the law of production of the emanation, and that the maximum radio-activity will be approximately normal. As metallic radium is much more volatile than barium, we propose to purify it by sublimation *in vacuo* on a cold metal plate.

A note in the Electrical Engineer referring to preserving telegraph poles states that the method proposed by the French physicist Boucherie, viz., to dip the lower end of the trunk in the preservative solution so that it rises up and displaces the sap, has been objected to by German engineers on the ground that it only answers with freshly felled trees cut down at the right time of year, and having undamaged bark, and besides that, far more preservative is necessary than when the usual method of forcing the preservative into the wood at high pressure is adopted. Where, however, pressure plant is unavailable it answers fairly well, and certainly increases the life of the pole very considerably, although not so much, of course, as the pressure impregnation method of preserving timber. Copper sulphate is now most generally used, but its action is weak, and three quantities are wanted—three times as much as can be sucked up in the Boucherie process. Nearly the same can be said of zinc chloride, but nevertheless that salt is both cheaper and stronger. Bichloride of mercury is expensive, but very effective. Creosote oils are largely used, but are inapplicable except to coniferous trees. Fluorides, especially zinc fluoride and sodium fluoride, have been used in Austria with good results. Either has five or six times the power of copper sulphate.



SPIRAL NEBULÆ PHOTOGRAPHED AT LICK OBSERVATORY.

H 11,730, Ursae Majoris.
H V43, Ursae Majoris.
M 100, Comae Berenices.

M 99, Comae Berenices.
M 61, Virginis.
M 88, Comae Berenices.

ARTIFICIAL CAMPHOR.

ITS INDUSTRIAL FUTURE.

BY G. BLANC.

No surprise was created in 1903 by the announcement that an American firm had discovered a method of producing synthetic camphor at a price which would enable it to compete on favorable terms with the natural product. Organic chemistry had given birth to many other marvels—artificial indigo, for example—and in numerous instances the chemist appeared to have equaled and even surpassed nature in cheapness, as well as in quality. Furthermore, it was generally suspected that the new synthetic camphor was obtained from oil of turpentine, for it was known that this transformation could be effected, at least in theory, by a very simple process.

Since this announcement was made, numerous patents for the synthetic production of camphor have been issued, but the demand for natural camphor has not been affected thereby. We hear a great deal about synthetic camphor, but only Japanese camphor is found in the market. Does this mean that artificial camphor is a myth? This conclusion cannot be authoritatively affirmed or denied, as I shall endeavor to show. Before doing so, however, it will be desirable to explain the state of the camphor market, in order to show the conditions which must be met by the manufacturers of synthetic camphor.

Natural camphor is a vegetable product which forms the subject of a very active commerce. It is used largely in pharmacy, but still more extensively in the manufacture of celluloid, which absorbs 80 per cent of the total production. Camphor is supposed to be used in making some varieties of smokeless powder, but only a comparatively small quantity is consumed in this way. Camphor is obtained from the *Laurus camphora*, a tree which grows in southeastern Asia, principally in the island of Formosa and the southern provinces of China and Japan. The method of extraction is extremely simple and crude. The tree is felled and is cut up into small pieces, which are distilled with water in very primitive apparatus. The camphor, together with an essential oil, called oil of camphor, passes over and condenses with the steam. After it has been partially dried by exposure to the air, it constitutes crude camphor, and is shipped to the refineries for purification.

In Japan and Formosa the trade in camphor is a government monopoly. By a law enacted in 1903, the producer is compelled to sell to the government, at a price fixed in advance, all of the camphor which he collects from his lands and concessions. The monopoly markets the camphor through commercial agents. In the last four or five years the average annual production of Japanese camphor has been about six million *kins*, or eight million pounds. One-fifth of this quantity is produced in Japan proper, and the rest in Formosa.

The production of Chinese camphor is very irregular. It exceeded two million pounds in 1907, but amounted to little more than one million pounds in 1908. The method of extraction, which is even more primitive than that employed in Japan and Formosa, and the difficulty of transportation to the coast, force the dealers in Chinese camphor to accept the price fixed by the Japanese. In short, Japan is the chief producer of camphor and controls the camphor market of the world.

European and American purchasers of camphor have made many attempts to emancipate themselves from the domination of Japan. Camphor trees have been planted, and have thriven, in California, India, Ceylon, Tonkin, German Africa, and even in Italy. Unfortunately, however, the conditions of competition are all in favor of Japan, which possesses a vast heritage of trees, some of which are more than a century old, while her rivals have only young trees, which yield very little camphor per acre. For this reason effective competition is quite impossible at present, and it will not become possible until the Japanese producers shall have felled all of their old trees and become dependent on the young growth. This condition will soon be brought about if the demand for camphor continues to increase at its present rate.

In regard to the production of natural camphor, therefore, Japan will remain mistress of the situation for some time to come; that is, until she shall have exhausted her patrimony.

Now let us see what chances of commercial success can be found for synthetic camphor. The synthesis of camphor is comparatively simple and well understood. It has been known for more than a century that pinene, a cyclic hydrocarbon of the formula $C^{10}H^{16}$, is capable of combining with the elements of hydrochloric acid to form a solid substance which resembles camphor in appearance, and was formerly known as "artificial camphor." This substance is the mono-hydrochlorate of pinene, or chloride of bornyl, $C^{10}H^{17}Cl$.

Berthelot discovered, long ago, that this compound, when treated with stearates or certain other salts at a suitable temperature, loses the elements of hydrochloric acid and becomes converted into a sodium hydrocarbon, which is isomeric with pinene and is known as camphene. Berthelot found, also, that camphene, $C^{10}H^{16}$, could be converted into camphor, $C^{10}H^{16}O$, by means of certain oxidizing agents. Here, then, is a first method of effecting the synthesis of camphor.

Bertram and Walbaum found that camphene, treated with certain organic acids and a trace of sulphuric acid, yielded esters of isoborneol, a secondary alcohol which is also converted into camphor by oxidation. Other chemists discovered that camphene and an ester of isoborneol can be produced together by treating the hydrochlorate of pinene with an organic acid, in presence of certain salts. Finally, it was discovered by Bouchardat that pinene can be converted directly into esters of isoborneol, by the action of certain organic acids.

The industrial synthesis of camphor is based upon these various transformations, which may be exhibited collectively by means of the following diagram:

$$\begin{tikzcd}
\text{Pinene} \arrow[r] \arrow[dd] & \text{Monochlorhydrate of pinene} \arrow[d] \arrow[ddl] \\
 & \text{Camphene} \arrow[d] \arrow[dl] \\
\text{Isoborneol} & \text{Camphor}
\end{tikzcd}$$

All of these transformations have long been known and are classical. The industrial problem, with which we are now concerned, is to effect the transformations in conditions of maximum efficiency and minimum expense for apparatus, material, and labor.

When regarded from this point of view, the patented processes for the synthesis of camphor may conveniently be divided into two classes. The first class comprises the processes in which pinene is first converted into its monochlorhydrate, which is then transformed into esters of isoborneol, either directly or by passing through the intermediate stage of camphene. The second class includes the processes in which pinene is converted directly into esters of isoborneol. None of the patented processes employs the direct conversion of camphene into camphor.

The first class includes one group (*a*) of processes in which the monochlorhydrate of pinene is converted directly into esters of isoborneol, camphene being formed as a by-product, or not at all; and a group (*b*) in which the pinene compound is transformed intentionally and exclusively into camphene, which is subsequently converted into isoborneol.

(*a*) The researches of Wuertz proved that chlorinated derivatives of hydrocarbons cannot be directly saponified, or converted into alcohols, by the action of caustic alkalies, but that this transformation can be effected, if the chlorinated compounds are first converted into acetates. Theoretically, therefore, the acetate of isobornyl can be obtained by heating a mixture of chlorhydrate of pinene, an acetate, and free acetic acid. This reaction forms the basis of several patented processes which employ, respectively, acetic acid with traces of zinc salts, sodium acetate with a little zinc acetate, nascent zinc acetate (obtained by adding acetic acid and pulverized zinc to the mixture), calcium acetate, zinc acetate, and lead acetate. One process, for the sake of variety, employs formic acid with the formate of zinc, copper, or iron. The patents give no precise details concerning the method of operation, but it is evident that a very large quantity of acetic acid is required. In one process 500 parts of acetic acid are employed in treating 172 parts of chlorhydrate of pinene. Furthermore, the operation must be conducted in closed vessels at a high temperature and therefore under high pressure, so that costly and comparatively short-lived apparatus is required. The acetic acid cannot be entirely recuperated, and the efficiency of the process, which is not given, cannot be very high. Part of the chlorhydrate of pinene, perhaps 25 or 30 per cent, is converted directly into acetate of isobornyl. The rest is transformed into camphene and other hydrocarbons, which must be separated from the acetic acid by fractional distillations involving considerable loss. There is also a loss of at least 20 per cent in the conversion of the pinene into chlorhydrate, and after the acetate of isobornyl has been obtained additional operations are required to saponify it, or convert it into the corresponding alcohol, isoborneol, and to oxidize the latter to camphor.

At the present price of camphor, less than 40 cents per pound, no such long and complex method of synthesis could have any chance of commercial success unless each of the successive transformations could be effected, and the reagents recuperated, without loss, which is very far from being the case.

(*b*) The chlorhydrate of pinene can be converted into camphene by heating it with alkalies, oxides of the alkaline earth metals, organic bases, or the salts of certain metals. Various patented processes based on this principle employ, respectively: organic salts or zinc, iron, and copper, with or without the addition of zinc chloride; a solution of soda heated to about 40 deg. C.; an alkaline solution of the sodium salt of paratoluene-sulphonic acid; pyridine; nicotine; quinoline; calcium phenolate; lead stearate; and an alkaline solution of sodium phenolate or naphthalate. Of more serious interest is a process which employs gaseous ammonia and effects the transformation with a loss of only 10 per cent. This process requires elaborate and delicate apparatus, but it is certainly capable of producing camphene cheaply. Unfortunately, however, the camphene cannot be cheaply converted into isoborneol. It is not impossible that some improvement of Berthelot's method of converting camphene directly into camphor was employed secretly and profitably by some shrewd manufacturer during the war between Russia and Japan, when the price of camphor rose to $1.30 per pound.

Let us now consider the second class of patented processes, in which pinene is converted directly into isoborneol or its esters. One patent claims the employment, as the agent of this transformation, of organic acids heated to 400 deg. F. A second, more modest, claims only the employment of benzoic acid. A third improves on the second by the addition of pulverized zinc. In a fourth process, pinene is heated with salicylic acid for fifty hours, during which the temperature is gradually increased to 266 deg. F.

Of more practical interest is an American process, in which pinene is heated with dry oxalic acid to a temperature not exceeding 248 deg. F., producing the formate of isobornyl, which is separated by fractional distillation and is easily converted into isoborneol. In a German improvement of this process, carbon tetrachloride and a small quantity of ammonium chloride are added to the mixture and the temperature is kept below 122 deg. F. In simplicity of operation and apparatus this improved process is far superior to all others, and, in the writer's opinion, it is the only one which offers any hope of commercial success at the present time. It is difficult to form an exact estimate of the cost of producing camphor by this process, but assuming a probable yield equal to 40 per cent of the pinene consumed and the price of oil of turpentine as 9 cents per pound, the cost of the synthetic camphor should be between 45 and 55 cents per pound. This process, and possibly two of the first class, could have been worked profitably in the period of inflated prices, but there is good reason to believe that the production of synthetic camphor has now practically ceased, for any considerable activity would produce on the turpentine market an effect of which no evidence is discernible.

I have hitherto omitted all mention of patented processes for the transformation of isoborneol into camphor. Various patents have been issued, but isoborneol can be converted into camphor by numerous well-known and unpatentable methods, employing the ordinary oxidizing agents (chromic and nitric acids, permanganates, etc.).

From this discussion it appears that synthetic camphor cannot compete with natural camphor at present prices, and the game of the Japanese monopoly is evidently to keep the price low enough to shut down, and even to annihilate, the German factories, for an expensive plant cannot long be kept idle.

How long this state of affairs will continue is difficult to predict. In the first place, the production of Japanese camphor is constantly becoming more difficult. The trees which are felled are too old to make a new growth and the young trees which are being set out will not become productive in less than thirty years. The vast camphor forests of Formosa are still far from being exhausted, but the coasts have been stripped almost bare and the exploitation of the in-

terior is made difficult by many obstacles, in addition to the hostility of the savage natives. When all of the accessible old trees shall have been destroyed the young ones will quickly follow. The coming of this day of evil could be postponed by allowing the trees to stand and collecting the leaves, which are twice as rich in camphor as the wood, but it is doubtful if the leaves could be harvested economically and the trees would probably not long survive this treatment. Hence a great decrease in the supply of natural camphor is almost sure to occur, sooner or later.

In the meantime, however, the demand may have dwindled to insignificance. It has already been stated that the principal demand is from the celluloid industry. More than four hundred substitutes for camphor, as a factor in the production of celluloid, have already been proposed. This great number indicates that none of the proposed substitutes is satisfactory, but there is no reason to assume that a good substitute will not be found some day. Furthermore, celluloid is so dangerous a substance that its manufacture may be prohibited at any time, and the researches which are now in progress in regard to the acetates of cellulose promise soon to furnish a perfect substitute, which will require no camphor for its production.

To summarize the subject in a few words: synthetic camphor cannot compete with natural camphor at present prices and, although a scarcity of natural camphor may be expected to occur before many years have elapsed, the celluloid industry may vanish in the meantime, leaving the question destitute of practical interest.—Translated for the Scientific American Supplement from Revue des Sciences.

ELECTRICAL RADIATIONS IN NATURE.

THE ELECTRICAL PHENOMENA OF THE SUN AND STARS.

BY PROF. E. GEHRCKE.

The recently discovered electrical radiations, the cathode, anode, canal, Alpha and Beta rays, were made perceptible by the progress of physical and chemical experimentation. Even the possibility of the existence of these rays was not suspected in former centuries. With other radiations, like those of light and radiant heat, the case is different. The effects and many of the properties of these rays were known long before their nature was investigated by physicists and they were proved to be the results of a wave motion. It required very sensitive instruments and methods of observation, combined with the skill and genius of a few eminent scientists, to discover and study the rays emitted by radium and the other radioactive elements which had led an unsuspected existence in certain minerals. In the case of the cathode, canal, and anode rays, it was necessary to perfect the technical methods of producing high vacua and high voltages before physicists could analyze the luminosity which had long been observed in rarefied gases in certain conditions, and thus to discover the electric radiations of which we are speaking.

Hence the greater surprise will be evoked by the assertion that these electric radiations occur also in untrammeled nature, and that they have manifested themselves to the human eye long before they were discovered in the laboratory.

The effects of the Alpha and Beta rays emitted by radioactive bodies are, however, so small that we can scarcely assume that these rays had been detected before their experimental production. The case of the cathode and anode rays is different. We may assert that the sun is a rich source of these rays, and we will proceed to prove this assertion.

The sun is analogous to a body which is incandescent in a vacuum. That the sun is very hot needs no special proof, and that the density of the matter in the vicinity of the glowing disk of the sun, the so-called photosphere, must be very small, is a necessary conclusion from various observed facts. For example, the passage of comets through the solar atmosphere has been observed to within a few minutes' distance from the photosphere, and yet the paths of the comets have not shown the slightest perturbation. The velocity of the comets, which themselves consist of very attenuated matter, has occasionally attained several hundred miles per second during this passage through the solar atmosphere, or, as it is also called, the corona.

Hence, we may regard the sun as an intensely hot body surrounded by an atmosphere of very small density. From this it follows that cathode rays must be emitted by the sun, for every body, incandescent and in a vacuum, sends forth the electrons, or negatively charged particles, of which these cathode rays consist. In total eclipses of the sun peculiar radiating lines of light are sometimes observed, the so-called coronal rays or streamers, which often extend outward to great distances, equal to many times the sun's diameter. The similarity of these coronal rays to streams of negative electrons immediately suggests itself, and if such coronal streamers had not been actually observed, we would be led by the foregoing considerations to seek them. It is only the intense brightness of the disk of the sun that makes the corona ordinarily invisible. In solar eclipses the photosphere is hidden by the moon, and the corona appears as a glowing coronet surrounding the dark disk of our satellite.

Even the old Greek writer Plutarch mentions the fact that in a solar eclipse a mass of light appeared surrounding the sun. A more detailed description of the phenomenon dates from the year 1239. In 1560 Clarius described the corona which appeared in a solar eclipse, and since that date the phenomenon has been studied by thousands of observers. But that the sun may be a source of cathode rays, was first suggested by Goldstein in 1881.

As a further consequence of this theory of the sun's constitution, it appears that the sun must acquire a positive electric charge through this continual loss of negative electricity. The view that the sun is positively charged appears to have been first expressed by Arrhenius. Hence it may be expected that, in certain conditions, positive rays may also be emitted by the sun. Pringsheim has suggested that the great and rapidly varying velocities of the masses of glowing gas, the so-called protuberances, which are frequently expelled from the sun, may be caused by electric forces accelerating the movements of positively charged particles, or ions. On this theory the protuberances are simply positive electric radiations of the character of the canal and anode rays. As a matter of fact, the velocities of the eruptive protuberances are of the same order of magnitude as those of the rays produced in Geissler tubes, and often exceed one hundred miles per second. In the spectrum of the protuberances, the lines of hydrogen, helium, and calcium are most prominent. These are sometimes accompanied by the lines of strontium, magnesium, barium, sodium, iron, and other elements, all of which are capable of emitting canal and anode rays when in sufficiently rarefied condition and under the influence of an adequate fall of potential. There are many other facts which make probable the identity of the eruptive solar protuberances with the positive radiations of Geissler tubes. The spectrum of hydrogen shown by the protuberances consists only of the three lines $H\alpha$, $H\beta$, $H\gamma$, and these three lines also constitute the spectrum of the hydrogen canal rays. The calcium lines *H* and *K* of the protuberances are especially prominent, according to Reichenheim, in the spectrum of calcium anode rays, while a great many other calcium lines, which can be produced by the electric arc and otherwise, are absent both from the spectrum of the protuberances and from that of the anode rays. When a protuberance is expelled from the sun, its point of origin usually becomes dark, forming a sun spot. Hale has concluded from his discovery of the Zeeman effect on the sun, and from the direction of rotation of the cyclonic sun spots, that these spots must be negatively charged. This result is easily intelligible in the light of our theory of protuberances, for a negative charge must be produced by the expulsion of the positively charged protuberance. On this theory a sun spot represents a local cathode in the sun, and consequently must emit cathode rays.

During an eclipse of the sun in 1901, Perrine obtained a photograph of the corona which showed only one streamer, rising from the only spot which was then visible and which was situated exactly on the limb of the sun. Although our sun is to be regarded as an incandescent anode which in certain conditions emits anode rays represented by the protuberances, the local losses of positive charge produced by the emission of these rays may create cathodes, which emit cathode rays, at the parts called sun spots. That these cathode rays, which can be detected most readily in the coronal streamers observed at eclipses, extend to far greater distances than the positive protuberances, is explained very simply by the difference in mass of the negative and positive particles. The "reach" of electrons is much greater than that of ions. The reach of the positive rays should correspond to that of the protuberances, and those protuberances which consist of the finest particles, i. e., of hydrogen and helium atoms, should be the highest. Perhaps these considerations will serve to explain the observed differences in level of the various elements in the sun, as a function of atomic weight.

According to the theory here set forth, the luminous phenomena of the solar surface are really electrical phenomena analogous to terrestrial thunderstorms. Owing to the high atmospheric pressure at the earth's surface, the electrical discharges here take the form of sparks or flashes of lightning; but on the sun, where the pressure above the protuberances must be very small, we would expect to find a silent luminous discharge like that of a Geissler tube, accompanied by positive and negative electric radiations.

It is probable that those fixed stars which are in a physical state similar to that of the sun, also emit positive and negative rays. Upon the earth itself electric rays may occasionally be produced, especially in the highest strata of the atmosphere. Certain phenomena of the aurora may possibly be caused by such rays. At all events, it is interesting to note that the cathode and anode rays, which at first glance appear to be purely artificial laboratory products, may and apparently must be produced also without human agency.—Umschau.

Before the British Association for the Advancement of Science, Mr. W. Crookes read an address, in which he said that he was troubled by the growing popularization of anthropology on the one hand, and lest amateurism should prove a danger to the scientific side of anthropology on the other. The remedy appeared to him to consist in the careful preparation of a trained staff, who would sift, arrange, and co-ordinate the facts already collected by non-scientific observers; initiate and control special investigations, and also organize in a systematic way the collection of specimens for home and colonial museums. "Assuming, then, that in the near future anthropological inquiries will be organized on practical lines, I invite your attention to some special problems in India which deserve intensive study, and which can be solved in no other way. India is a most promising field for such inquiries. Here the student of comparative religion can trace with more precision than is possible in any other part of the empire, the development of animism and the interaction on it of the forces represented by Buddhism, Hinduism, Islam, and Christianity. The anthropologist can observe the most varied types of moral and material culture, from those represented by the heirs of its historic civilization down to forest and depressed tribes little raised above the level of savagery." After discussing some of the problems of Indian culture on which further light is desirable, and the origin and development of caste, Mr. Crookes considered some of the grounds for racial unrest which have been a source of anxiety to the government. In this context, he remarked: "In India at the present time 'the old order changeth, yielding place to new'; and at no period in the history of our rule was it more necessary to effect a reconciliation between the foreigner and the native. While the tabus of marriage relations and commensality will for an indefinite period prevent the amalgamation of the races, much of the present disquiet is due to ignorance and misunderstanding on both sides. The religious and social movements now in progress deserve the attentive study of the British people. In religion various attempts are being made to free Hinduism from some of its most obvious corruptions, to harmonize eastern and western ideals, and to elevate the former so as to enable them to resist the pressure of the latter. Such is Vedantism, a revival of the ancient pantheistic philosophy, which not only claims supremacy in India, but asserts that its mission is to replace the dying faiths of the western world. The spread of monotheism, as represented by Bhagavata beliefs, is equally noteworthy; and the effect of the revival of the cults of Ganpati, god of luck, and of Sivaji, the Mahratta hero, on the political situation in the Deccan deserve the most careful consideration."

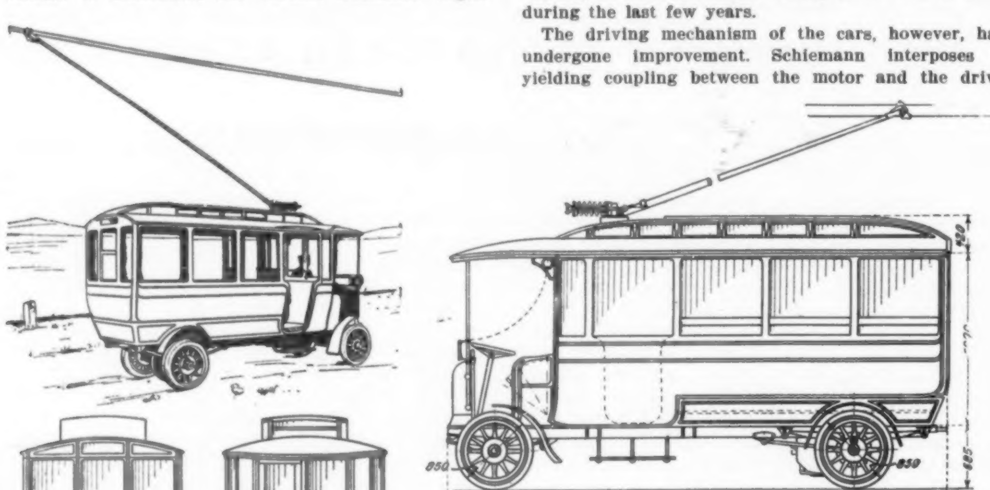
A new mechanical device for registering the number of passengers as they pass into the McAdoo Hudson River tunnels is being installed for trial at the Hoboken, N. J., station. By interrupting a stream of compressed air, which holds an electric circuit open in an instrument across the passageway, each person completes the circuit and is registered. If this instrument continues to work successfully it may do away with the ticket checker. It was invented by H. A. Reishel, who has patented it.

TRACKLESS ELECTRIC ROADS.

THE PRESENT STATE OF THE ART.

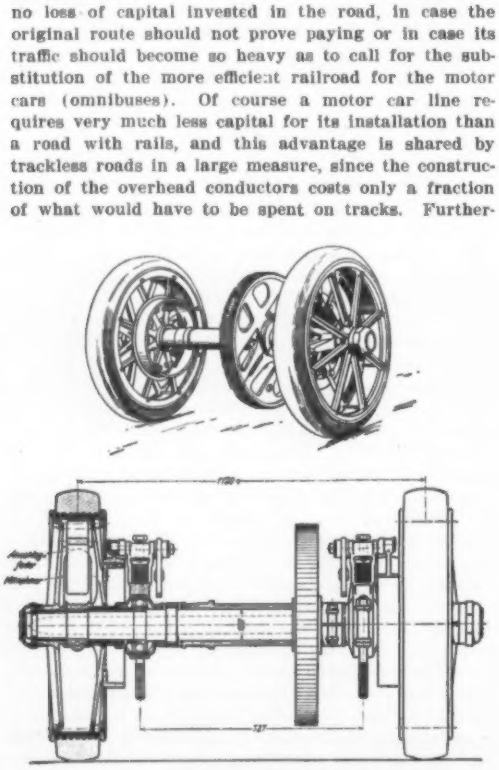
BY A. HELLER.

The increased attention now directed toward trackless electric roads is probably due to the unusual spread of electric current distribution from long-distance power stations. Several years ago, in the 1906 volume of Zeitschrift des Vereins Deutscher Ingenieure, page 763, I have referred to this conveyance which as it were forms a link between automobiles proper and electric street railways, so that a few words will suffice here to point out the advantages of trackless roads.



Figs. 1 to 5.—Motor Passenger Car for Trackless Roads.

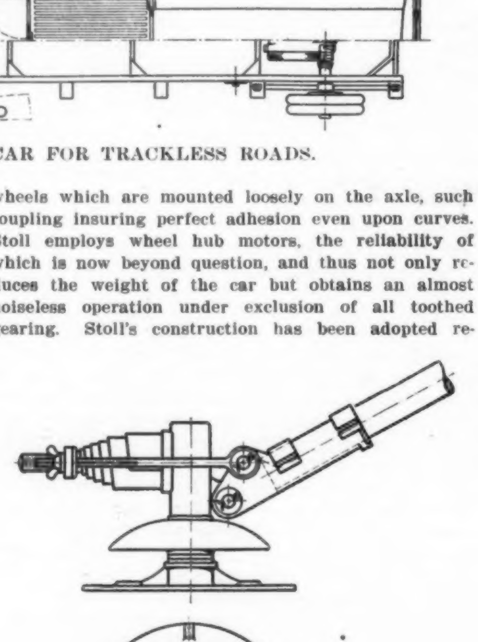
The most important advantage offered by the use of motor cars for public cross-country traffic is the "mobility" of the line, which allows the entire traffic to be transferred to a different route, with practically no loss of capital invested in the road, in case the original route should not prove paying or in case its traffic should become so heavy as to call for the substitution of the more efficient railroad for the motor cars (omnibuses). Of course a motor car line requires very much less capital for its installation than a road with rails, and this advantage is shared by trackless roads in a large measure, since the construction of the overhead conductors costs only a fraction of what would have to be spent on tracks. Furthermore, if the route is changed, the overhead conductors can be used in the new location. Again, if the road is later converted into an electric railroad (ordinary trolley road) the previously laid overhead wires may be used as they are.



Figs. 6 and 7.—Motor Car Axle.

Another advantage which a motorbus line and almost equally a trackless electric road have over a railroad, is the free mobility of the cars. The trolleys or current-collectors employed for this purpose are either long pole collectors (Schiemann) or towed collectors (Stoll), no radical changes having been made in them during the last few years.

The driving mechanism of the cars, however, has undergone improvement. Schiemann interposes a yielding coupling between the motor and the drive wheels which are mounted loosely on the axle, such coupling insuring perfect adhesion even upon curves. Stoll employs wheel hub motors, the reliability of which is now beyond question, and thus not only reduces the weight of the car but obtains an almost noiseless operation under exclusion of all toothed gearing. Stoll's construction has been adopted recently by the Oesterreichische Daimler-Motoren-Gesellschaft in Wiener Neustadt.



Figs. 9 and 10.—Spring Support.

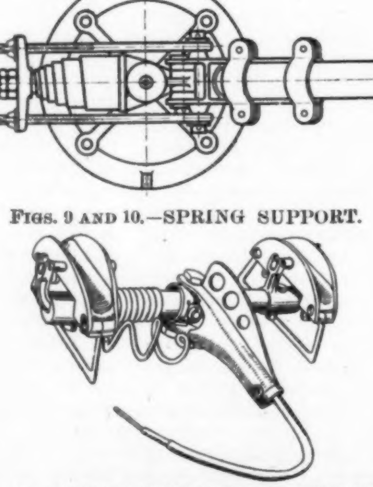


Fig. 11.—Slide Contacts of Current Collector.

Finally, as regards operating costs, it must be conceded that on account of the greater rolling friction the current consumption per ton-kilometer exceeds the average of electric street railroads by about from 25 to 100 per cent, according to the construction of the cars. This difference, however, is partly compensated by the fact that the cars of trackless roads can be of lighter construction so that the weight of the rolling stock per passenger is smaller than with street railroad cars, and this difference is quite an important factor in determining the average power on lines having many grades. It should also be borne in mind that the cost of electric current, in the case of a trackless road operated in conjunction with a cross-country power station, is not of such great importance as compared with the amount required for interest, renewal of tires, and depreciation. Moreover, the power company, if it does not also operate the trackless road, will certainly offer material concessions in charges for current, since such policy will no doubt lead to an increased consumption.

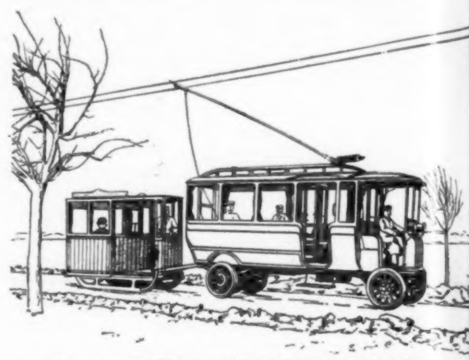
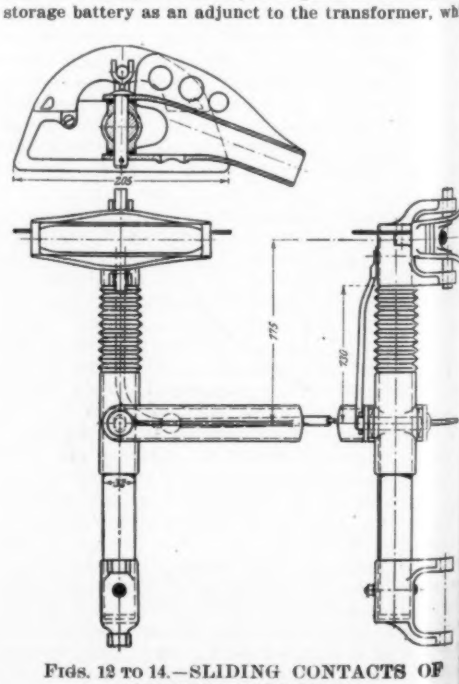


Fig. 8.—Motor Car with Trailer.

One of the most recent installations of Schiemann's system (adopted by the Gesellschaft für gleislose Bahnen Max Schiemann & Co. in Wurzen) has been made in Drammen, Norway, a town of 35,000 inhabitants, where, upon an order placed by the Aktieselskabet Drammens Elektriske Bane, a traffic was inaugurated with six motor cars on two lines running on both banks of the Drammens-Elv and having a length of 2 and 3.5 kilometers respectively (slightly below and above two miles). The two lines are connected by a light wooden bridge with approaches having 10 per cent grades. The operating current is taken from a 40-kilometer transmission line of a long-distance power station by means of a 60-kilowatt transformer converting alternating into continuous current. Since, however, the power station does not supply any current on Sunday forenoons, it is planned to employ a storage battery as an adjunct to the transformer, while at present the traffic must be interrupted on Sunday mornings or carried on with horses. According to reports received so far this road has shown satisfactory development, so that two additional cars have been supplied and two more ordered.



Figs. 12 to 14.—Sliding Contacts of Current Collector.

The car (Figs. 1 to 5) weighs 3 tons without pas-

sengers, and is fitted with a main current motor of from 15 to 22 horse-power which drives the rear axle by means of toothed gearing with a reduction ratio of 1 to 6. With 20 passengers, a speed up to 20 kilometers (12½ miles) per hour is obtainable. The cars have side entrances and, as distinguished from former constructions, steering is effected by swinging each front wheel about its individual steering kunckle (as

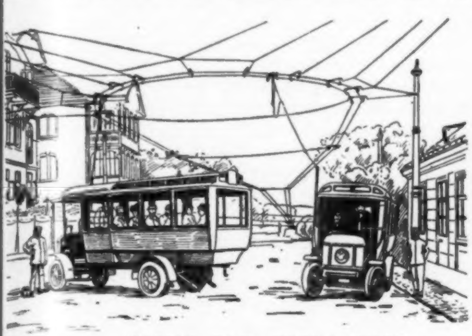


Fig. 15.—MOTOR CAR, STOLL TYPE.

in automobiles) instead of employing a fifth wheel, and the drive is applied to the rear wheels, both of these improvements effecting a considerable increase in the mobility of the car in narrow streets.

A remarkable feature of these cars is the distribu-

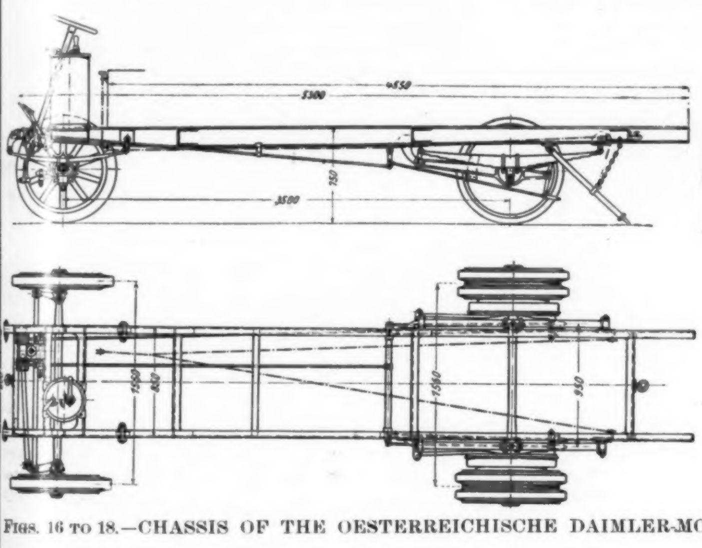
the sliding wheel often takes too much current, at the expense of the other motor's supply; if the motors are connected in parallel, there is danger that the motor

ment of the wheels is limited. According to German patent 147,256 Schiemann accomplishes this by mounting the driving wheels loosely upon the axle and

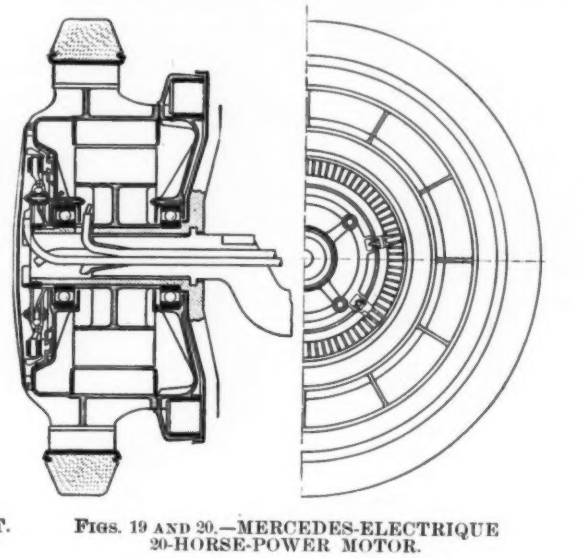
Fig. 21.—MOTOR CAR, STOLL TYPE, FOUR-WHEEL DRIVE.

of the wheel which does not slide, will be overloaded to such an extent that either this wheel also will begin to slide, or the fuse will burn out.

providing each of them with a transmission spring working in conjunction with a driving projection secured to the driving axle. Incidentally, this con-

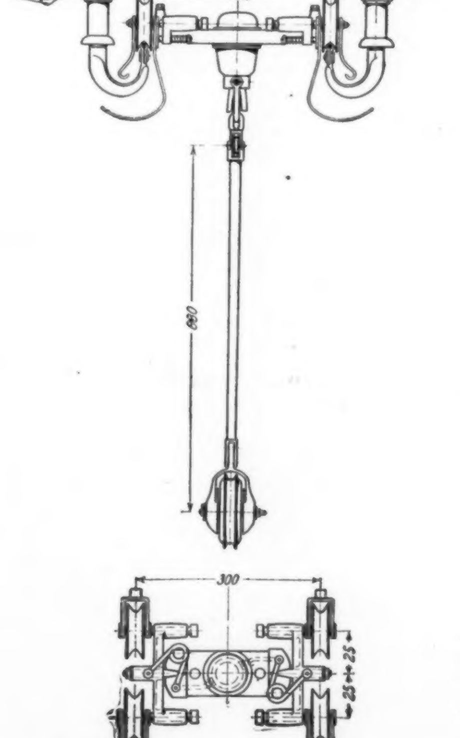


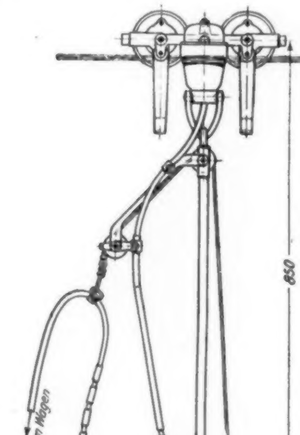
Figs. 16 to 18.—CHASSIS OF THE OESTERREICHISCHE DAIMLER-MOTOREN-GESELLSCHAFT.



Figs. 19 and 20.—MERCEDES-ELECTRIQUE 20-HORSE-POWER MOTOR.

tion of power from the motor to the two driving wheels which may also be applied in cases where the front wheels are driving wheels and the front axle swings bodily for steering). Experience with automobiles has





Figs. 22 to 25.—STOLL TYPE CURRENT COLLECTOR WITH AUTOMATIC EXTENSION OF CABLE BY ROPE DRUM ON THE PENDULUM WEIGHT.

shown that the drive wheels should be movable relatively to each other, in order that they may not slip in curves. Differential gearing of the type used for automobiles has the defect that the equal distribution of power depends entirely upon adhesion. If one of the wheels should begin to slip on account of reduced adhesion, the entire power will be transmitted to that wheel, which will revolve rapidly, while the other wheel is almost stationary. This peculiarity of differential gearing is likely to cause trouble especially on upgrades, where the full power of adhesion is required. A similar difficulty is experienced with electric automobiles having individual motors for the drive wheels. If the motors are connected in series, the motor of

Since the real purpose of a differential gearing is to permit the drive wheels to travel through paths of different length when taking curves, it seemed natural to devise constructions in which the relative move-

struction minimizes the jars due to careless starting and to unevenness of the road. It will be understood that each wheel is thus capable of a limited angular movement relatively to the axle and therefore relatively to the other wheel, this freedom being sufficient for traveling on curves. Moreover, the projection and spring oppose an increasing resistance to the slipping of the wheels. This transmission has proved very satisfactory and, as shown in Fig. 8, upon a snow-covered road the motor car was able to tow a trailing sleigh for 10 passengers.

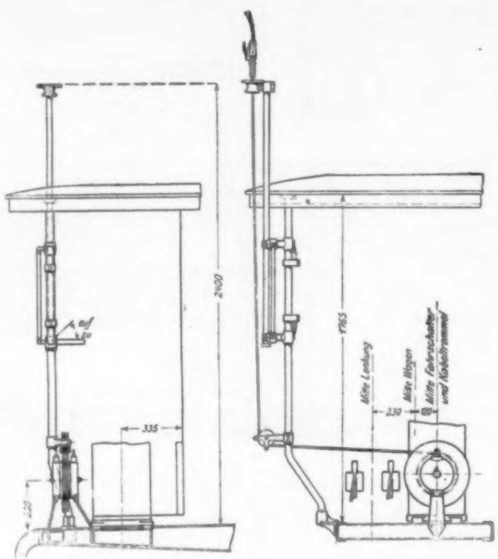
The operating current, of 500 volts, is supplied to the car by double-pole collectors, the poles of which are mounted on the roof of the car and are pressed upwardly by springs of adjustable tension (Figs. 9 and 10), the sliding shoes (Figs. 11 to 14) adjusting them-

selves automatically to the overhead conductor, irrespective of the car's movements. The pole itself forms one of the current conductors, the other conductor pressing within the pole. In the Drammen road the distance between the overhead wires is only 150 millimeters instead of 350 as in Figs. 11 to 14. This current collector is described in German patent 220,174, and has for its chief object to enable simple automatic overhead switches to be built into the overhead line, without using any links or crossings. Furthermore, this construction insures the proper supply of current even if the car has to travel as much as 3 meters to one side of the overhead wires.

Trackless electric roads are intended only for moderate traffic, and for this reason the overhead wires form generally a single track. If two cars traveling in opposite directions on the same wires should meet, one of them will proceed undisturbed, the other must turn out and pull down its current collector while passing. The pole can be drawn down by the motorman from his stand. It is not necessary to stop the car while it is disconnected from the overhead wire, but it may be allowed to roll on by its momentum.

The total length of the eleven lines constructed and now in operation according to this system, for the conveyance of passengers and freight, is 45½ kilometers (about 28¼ miles), and the total number of motor cars and locomotives is 28.

The Stoll type of trackless electric roads owes its recent development, as stated above, to the use of wheel hub motors for heavy automobiles, particularly motor omnibuses, the cars of such roads (Fig. 15) being almost identical with such omnibuses. Even the trucks and lower frame are similar to those of motor omnibuses, being made of pressed sheet metal; with the motors, controllers and other electrical appliances (but without the superstructure) this frame weighs but 1.7 tons. The motors are of the well-known Mercedes Electrique construction. Figs. 19 and 20 illustrate in cross-section and in side elevation respectively, a 20 horse-power motor for the rear axle, this motor being built into a wheel having a solid rubber tire, current being supplied through the hollow axle.



Figs. 26 and 27.—CONNECTION OF CABLE WITH CAR.

The motors, however, may also be built into the steering wheels, in which case the steering knuckle will be approximately in the plane of the wheel. For very steep mountain roads cars have been constructed with four driving wheels, Fig. 21. When traveling down hill, such cars may be braked electrically at each of the four wheels, thus avoiding a jamming of the wheels.

The car bodies are made with side entrances as a rule, the motorman acting as conductor also, and will hold 22 passengers. The total weight of the empty car is 2.5 tons.

The current collector, Figs. 22 to 25, consists of a four-wheel carriage (with ball-bearings) traveling on the bipolar overhead conductor and connected with the motor car by a flexible double cable from 10 to 12 meters long. The stability of this carriage is increased by suspending from it, by means of a long rod, a spring reel, the wire or rope of which draws the cable into a loop and takes up the pull exerted by the car so that this pull will not come on the portion of the cable which is secured to the carriage.

On the car the cable is connected by means of a removable plug switch, with a cable about 10 to 12 meters long, Figs. 26 and 27, which is kept taut by a special spring drum. The motorman is thus enabled to use practically the full width of the road irrespective of the position of the overhead wires. Furthermore, this detachable connection enables cars traveling in opposite directions, to pass each other readily, the motormen simply exchanging the plugs and current collectors, and then proceeding on their way.

Trackless roads of this type have been put in operation during the last two years upon eight lines having a total length of 23 kilometers (about 14.3 miles) and an equipment of 26 motor cars.—Zeitschrift des Vereins Deutscher Ingenieure.

THE STUDY OF SOLUTIONS.*

PAST THEORIES AND FUTURE RESEARCH.

BY DR. LOUIS KAHLENBERG.

Solutions have been known since earliest times, and the problems which they represent have been studied by a long line of very able investigators. All of the early work on solutions has been inseparably linked with the study of chemical phenomena. Indeed, up to the year 1887 chemical views of solutions have predominated. So for example, in his lectures delivered at Yale College in 1837, Benjamin Silliman, Sr., considered solutions as chemical compounds; and in his memorable work on theoretical chemistry which appeared in 1863, Hermann Kopp treated solutions as chemical compounds that exhibit variable proportions, which mode of treatment was retained by A. Horstmann when in 1883 he wrote the second volume of the new edition of Kopp's work, now known as Graham-Otto's "Lehrbuch der physikalischen und theoretischen Chemie." Ever since the days of Lavoisier, when the so-called law of definite proportions was first recognized, a distinction has been drawn between compounds which follow that law and combinations that do not. Chemical combinations which exhibit definite qualitative and quantitative composition that cannot be varied gradually by small increments arbitrarily chosen were soon termed definite chemical compounds, whereas solutions, whose composition may be varied gradually, quite arbitrarily—at least within certain limits—were regarded as indefinite chemical compounds, or compounds according to variable proportions. So Robert Bunsen used to teach that we may have compounds according to definite proportions and also compounds according to variable proportions, the latter compounds being the group known as solutions.

The careful quantitative investigation of solutions really dates from the time of Lavoisier, who, as is well known, introduced the balance into the chemical laboratory. Before this the observations made were generally only qualitative in character; at any rate they were often crude and faulty. The very fact that solutions were regarded as chemical compounds led to their study by much the same methods adopted for the investigation of definite chemical compounds, i. e., chemical compounds in the narrower sense in which the term is at present commonly used. So the qualitative composition and the quantitative composition of solutions were carefully studied. The density, the color, the boiling point, the specific heat, the optical activity, the thermal accompaniment of the formation of solutions and of their reactions with other substances, as well as their other physical, chemical and physiological properties, were studied in much the same way that these various properties were determined for definite chemical compounds. And yet, the fact that the composition of solutions may be varied gradually and arbitrarily within certain limits and that this cannot be done in the case of definite chemical compounds, has for nearly a whole century been considered to be the vital difference between a solution and a definite chemical compound, and this is quite proper.

To obtain a definite chemical compound in the pure state usually requires a considerable amount of work. The usual operations of purification as in vogue at present are crystallization, solution and precipitation, sublimation and distillation. By means of the so-called purification process a product is finally obtained whose composition does not change further, though the substance be subjected to further similar treatment. As F. Wald states it, a chemical compound is a phase whose composition remains constant though temperature, pressure and contact with other phases be varied within certain limits inside of which the substance in question is stable. In a sense then the so-called definite chemical compounds are really obtained in certain cases as the more resistant cleavage pieces resulting when the purification processes are applied. That the latter processes after all frequently represent rather violent treatment will probably not be gainsaid by any one.

The law of definite proportions was considered by Ostwald in his Faraday lecture, which in turn was discussed by others, among whom Benedicks voiced the sentiment that after all when closely scrutinized it becomes evident that there is an arbitrary element in judging as to when we really have a pure, definite compound before us, and that the matter of definite proportions is to some extent one of definition. As to the law of multiple proportions, this has been directly challenged by P. Duhem as a tenet that can neither be proved nor disproved, though I must frankly confess my inability to agree completely with him in his argument.

The year 1887 is noteworthy, for it brought both the van't Hoff theory of dilute solutions and the theory of electrolytic dissociation of Arrhenius. These theories really supplement each other, as is well known. They may well be called physical theories of solutions as distinct from the chemical views of solutions already mentioned. It is quite unnecessary to rehearse here the great activity that has resulted in the study of dilute solutions during the last two decades as a direct consequence of the theories of van't Hoff and Arrhenius. The pages of the history of chemistry that record this experimental work on dilute solutions will ever maintain their brilliant luster, for they reflect the enthusiastic efforts of scores of active young hands and minds that were urged on by a most inspiring leader, an able teacher and experimenter, and a most lovable man—Wilhelm Ostwald. Without him the theories of van't Hoff and Arrhenius would scarcely have gained a foothold.

But excellent as were many of the experimental acquisitions that were thus obtained as a result of these working hypotheses, time has shown that the latter have long since served their purpose, and that mere physical conceptions of solutions are untenable as an explanation of the phenomena actually observed. Furthermore, a theory which applies merely to very dilute solutions, and then only in an imperfect way, is quite untenable in the long run, even as a working hypothesis. It is not my purpose to enter upon a discussion of the numerous experimental researches which have made the theories of van't Hoff and Arrhenius untenable. These investigations have been published at various times during the last decade, and I have dwelt upon them in detail on previous occasions. It is quite safe to assume that they are sufficiently well known to all. Moreover, I frankly confess that I am glad to escape the task of recounting again the weaknesses of these views of solutions as exhibited by experimental facts, for in my younger days I was quite enthused with these hypotheses, and it was to me a great disappointment to find later that they were contradicted by so many experimental truths. It is rather my purpose to point out the direction in which experimental investigations made thus far have led us, and to attempt to indicate the line of attack which must be followed to insure success in the future, so far as this can at present be foreseen.

The data collected since 1887 in studying the various properties of solutions, though frequently gathered with the aid of the physical hypotheses already named, have nevertheless gradually and unerringly demonstrated that the chemical view of solutions is far nearer to the truth, than is the idea that a solution is a mere physical mixture. In this connection permit me to call attention to a few experimental illustrations.

When antimony trichloride and camphor are brought together the two solids liquefy each other, forming a thick syrupy solution, the proportions of the two ingredients of which may be varied within certain limits. Antimony trichloride and chloral hydrate similarly liquefy each other, though less readily. Again, camphor and chloral hydrate when in intimate contact with each other form a liquid. If now cane sugar or

* Address of the vice-president and chairman of Section C—Chemistry—American Association for the Advancement of Science.

paraffine be treated with antimony trichloride or with camphor or chloral hydrate no change will be observed. The question arises, why do antimony trichloride and camphor liquefy each other and cane sugar and camphor not? It is perfectly clear that all that we can say is that this is because of the specific nature of the substances themselves. In other words, antimony trichloride and camphor liquefy each other and sugar and camphor do not for reasons that are similar to those which we give as to why charcoal will burn and platinum will not. We may say that the mutual attraction, i. e., the affinity of antimony trichloride for camphor, is sufficient to overcome their cohesions, and so they unite and form the solutions. Now as to whether the antimony trichloride dissolves the camphor or the camphor the antimony trichloride is clearly an idle question. We may regard either the one or the other as the solvent, for this is obviously a purely arbitrary matter. Let us now raise the following question: In the syrupy liquid that has been formed by the action of antimony trichloride and camphor on each other, how much of the camphor present is combined with the antimony trichloride that has been employed? The answer is perfectly obvious, for clearly all of the antimony trichloride is combined with all of the camphor in the syrupy liquid that has been formed. One might as well ask the question: When mercury and oxygen unite to form mercuric oxide, how much of the oxygen present is united with the mercury that the oxide contains? Clearly here, too, all of the oxygen is united with all of the mercury present. When the solution of antimony trichloride and camphor is heated, the vapor obtained contains both of the ingredients. Similarly when we heat mercuric oxide the vapor contains mercury and oxygen. We see thus that the cases are essentially similar in character, the only difference being that in the case of the solution in question we have a compound according to variable proportions, whereas in the mercuric oxide we have a compound according to definite proportions.

Now when ice acts on sodium chloride is not the case quite similar to that of camphor and antimony trichloride? Suppose we knew of no temperature above 0 deg. C., would any one argue that the solid ice dissolved the solid salt in the process of forming the brine? Certainly not, we should say that the brine has been formed by the union of the ice with the salt. And here similarly the question as to how much of the salt in the brine is united with how much of the water in the latter is quite idle, for obviously all of the salt used has united with all of the ice. The case would clearly not be altered if we started with liquid water and solid salt and formed the brine by the interaction of the two substances. This view, that in a solution all of the substances present are united with one another just as all of the elements in a definite compound are combined with one another, is to my mind the only rational view we can take of the matter. It is not new; on the contrary, it is quite old. It has been held quite generally by scientists prior to 1887, when the physical theories came upon the stage and diverted attention into other channels, as already stated, with the result that the true nature of solutions has been thoroughly obscured. If now we dilute the brine with more water, does the water added combine further with the salt present? Most assuredly, for is not the vapor tension of a brine, however dilute, lower than that of pure water, and does not this show that the water in the brine experiences greater difficulty in evaporating because of the mutual attraction between the salt and the water? Were any of the latter uncombined with the salt of the brine, this uncombined water would show the same vapor tension as pure water; but a brine of the same vapor tension as pure water of the same temperature does not exist.

The phase rule of Willard Gibbs marks a great advance in the study of heterogeneous equilibrium. Through the practical work of Bancroft, Roozeboom, and numerous other able chemists, the phase rule has borne rich fruits. In all of this work the composition of the phases that are in equilibrium with one another under given conditions of temperature and pressure was carefully determined. This work has revolutionized solubility determinations, placing them upon an accurate scientific footing. Nowadays when the solubility of a compound is to be thoroughly investigated nothing less than the complete equilibrium curves of the compounds in question will suffice; but once the work is carefully done, it is final for all time. This is not the place to dwell upon all the various questions that have been cleared up by the application of the phase rule. It should here be emphasized, however, that the latter deals with the equilibrium of the various phases whose qualitative and quantitative composition is of course ascertained. As to the inner structure of any one of the phases the phase rule is able to tell us nothing. Indeed, in the study of single-phase chemistry, the phase rule is no help whatever. We may consider the investigation of the constitution of definite chemical compounds a part of single-phase chemistry, and we may similarly consider the question as to the inner nature of a solution (i. e., of a compound according to variable proportions) as a problem of single-phase chemistry. In the investigation of the constitution of single phases it is quite impossible to get along without hypotheses. While the phase rule does not involve even the atomic and molecular theories, these are at present indispensable tools in prying into the inner nature of any one phase. But in the study of solutions, interest centers not so much in the equilibrium between phases as in the inner structure of the latter themselves.

Our methods of ascertaining the structure of chemical compounds are guite numerous, but they readily fall into a few categories. So we argue as to the structure of a compound from its synthesis, from its analysis, from its behavior toward various other chemical agents, from alteration by the application of pressure, heat, electricity, light, and kindred agencies, and also from its various physical and physiological properties. Thus, for example, it has always been considered as sound reasoning that because red precipitate can be formed from mercury and oxygen, these substances are in red precipitate, which conclusion is verified by the fact that the latter compound may be decomposed into oxygen and mercury. There has never been any objection to the argument that if one of the elements actually enters into a compound during the latter's formation, or can be obtained from the compound either in the free state or in combination with other elements, that element is actually in the compound. So since calcium carbonate may be made from calcium, carbon, and oxygen, we argue that these elements and these only are contained in calcium carbonate. Again, when calcium carbonate is heated, calcium oxide and carbon dioxide, and these only, are obtained; and conversely calcium carbonate may be formed by the union of calcium oxide and carbon dioxide. These facts were duly expressed by the old dualistic formula for calcium carbonate $CaO.CO_2$ which consequently had much to commend it. Yet while we thus hold that the elements calcium, carbon and oxygen are in calcium carbonate, we do not argue that this compound contains calcium oxide and carbon dioxide, even though the last two substances will unite and thus form calcium carbonate, or though they may be obtained as decomposition products of the latter compound. We write our formula for calcium carbonate $CaCO_3$ because of the precipitation methods by which the compound may be prepared, and because of the formulæ that we assign to soluble carbonates on the basis of the products that they yield by electrolysis. We consequently hold that the carbon dioxide and lime that form when calcium carbonate is heated result from the rearrangement of the atoms and splitting of the compound on account of the violence to which it has been subjected by heating it very highly. Similarly, while we recognize that carbon, hydrogen, and oxygen, are contained in cane sugar, we do not argue that the latter consists of water and carbon, though these products may among others be obtained by heating sugar. Likewise we are loath to conclude that proteins contain amino acids, simply because these result as cleavage products when the proteins are subjected to certain rather drastic treatment.

Turning now, for example, to a compound like blue vitriol whose composition we are wont to express by the formula $CuSO_4.5H_2O$, to indicate that it consists of copper sulphate plus water, we find that the water may be driven off by heat properly applied and that the dehydrated copper sulphate remains behind. On heating the copper sulphate further it is decomposed into copper oxide and sulphur trioxide. If it were intended to express these changes by means of a formula, surely the old dualistic formula $CuO.SO_3.5H_2O$ would best indicate what has been observed. But here again we have departed from the idea that copper sulphate contains copper oxide and sulphur trioxide because upon electrolysis of an aqueous solution of copper sulphate, metallic copper, sulphuric acid and oxygen are obtained; while upon adding zinc or iron to a copper sulphate solution metallic copper is thrown out, and the sulphate of the more basic metal results. So far as the water content of blue vitriol crystals is concerned, we only know its relative amount and that it can be driven off by heat, higher temperatures being required to secure complete dehydration, while relatively lower temperatures will suffice to remove a large portion of the water. As to how this so-called water of crystallization is held, whether it is united with the copper sulphate simply as water molecules adhering to the copper sulphate molecule, or whether, like the oxygen and hydrogen content of the cane-sugar molecules, the oxygen and hydrogen in blue vitriol are united with the sulphur and copper in some more complicated way, is an open question. So far as the facts known are concerned, they are expressed by the formula $CuSO_4.5H_2O$, just as at one time the formula $CaO.CO_2$ expressed what was known about calcium carbonate. To me it would seem very probable that the hydrogen and oxygen content in blue vitriol is not present as water molecules clinging to the copper sulphate molecule, but some subtle experimental method, as yet quite unknown, is required to elucidate this matter, and until such a method is found we shall continue to write our formula for blue vitriol as we are wont to do. It is perhaps well in this connection to allude to the well-known fact that many salts containing water of crystallization can not be dehydrated by heating them, for when this is attempted not only water, but other ingredients as well, are driven off, in other words, further deep-seated decomposition occurs.

If crystals of blue vitriol be placed in water, a blue liquid is formed as a result of the action of the crystals and water on each other. This liquid we call a solution. The amount of water and blue vitriol used in its preparation may be varied arbitrarily within certain limits. For reasons already stated, this blue liquid contains no water that is not in combination with the salt present, and also no salt that is uncombined with the water. The fact is that this blue liquid is found to be perfectly homogeneous by all tests that we are able to apply. If we add more water to it, this additional water also combines with all of the salt present and the liquid is again homogeneous; and this dilution may be carried on indefinitely. If, on the other hand, we permit the blue liquid to evaporate, we thus decompose it by abstracting water from it. We say that the solution is becoming more concentrated. This change is a perfectly reversible one, and like all chemical changes, it follows the law of mass action. The abstraction of water from a solution of copper sulphate by means of heat is just as truly an act of decomposing that liquid as is the abstraction of carbon dioxide from lime stone when the latter is heated.

Blue vitriol is formed by the addition of water to anhydrous copper sulphate. The compound thus produced is quite stable at room temperature. If now we add anhydrous copper sulphate to crystals of blue vitriol, the latter lose part of their water content, which is taken up by the anhydrous salt till equilibrium is established. If, on the other hand, we treat the blue vitriol crystals with water, it is clear that we can not thus dehydrate the crystals. On the contrary, this added water will, because of mass action, tend to increase the stability of the complex which we represent by the formula $CuSO_4.5H_2O$, and to this complex all of the additional water present in the solution adds itself. What then is the formula of the hydrate contained in an aqueous copper sulphate solution at known temperature? This question is really an idle one, for since all of the copper sulphate present is combined with all of the water of the solution, the composition of the hydrate is clearly expressed by $CuSO_4.xH_2O$, where x represents the number of water molecules which the entire solution contains per each copper sulphate molecule; and so x increases as we dilute the solution and diminishes as we concentrate it. But this must not be taken as meaning that all of the water in a copper sulphate solution is equally strongly bound to the salt molecules. Indeed, in the case under consideration it is extremely probable that at least five molecules of water are more strongly bound to each copper sulphate molecule in the solution, for as the salt separates out, these five molecules remain in combination as a part of the compound. But while in the solution the copper sulphate molecule plus five molecules of water may be present as a nucleus to which the additional water molecules are attached, the force of attraction with which the outlying water molecules are held by the nucleus shades off so gradually as the radius of the sphere of influence increases that there is at no point any very sharp demarkation, and so it would be folly to attempt to ascribe any definite formula whatever to the hydrate existing in the solution. Attempts to deduce the formulæ of hydrates in solutions from the boiling points or freezing points of the latter are very far from the mark, though to be sure boiling-point and freezing-point curves do frequently show maxima and minima which are doubtless due to changes of intensity with which the water and salt molecules are held together as their relative number is changed. Furthermore, it is very significant that such maxima and minima in the boiling-point and freezing-point curves are found in the case of those substances, which, when they crystallize from the solution, do so with one or more molecules of the solvent attached as so-called crystal water. It is well known that at higher temperatures salts separate from solutions with less crystal water than at lower temperatures. Indeed at high temperatures the anhydrous salt is frequently in equilibrium with the saturated solution. So while at ordinary temperatures copper sulphate forms crystals with five molecules of water, at lower temperatures it may be obtained with seven molecules of crystal water. Now would it then be right to conclude from this that at room temperature the hydrate in the solution is $CuSO_4.5H_2O$ and at lower temperatures $CuSO_4.7H_2O$? Obviously not, but we may say that it is at least that indicated by the composition of the compound that separates. In the solution itself many additional

water molecules are combined with the salt molecules, and the force of attraction gradually shades off as the radius of the sphere of attraction from the nucleus outward increases so that it is quite impossible to ascribe any definite formula to the hydrate in the solution. (I should like to add parenthetically here that the recent attempts made to draw conclusions as to how many water molecules are attached to a portion of certain salts, from observations of changes of concentration that occur at the electrodes during electrolysis, are also based upon misapprehensions, but these details can not be taken up here.) It is, moreover, well known that when any physical property of a solution is studied at different temperatures the curve representing the alteration of that property with change of temperature does not show sharp points of inflection, indicating that whatever the internal alterations may be within the solution, they occur gradually rather than suddenly.

SCIENCE NOTES.

Messrs. Lacomte and Lainville presented samples of a milk powder at a recent meeting of the French agricultural society which is obtained by a new process. Instead of evaporating the milk by hot air or *in vacuo*, the authors' use the method of freezing in order to separate the water from the milk so that it can be afterward dried. The milk is placed in freezing tanks and is cooled to —2 deg. C. (28.4 deg. F.), when the water separates in the form of snowy crystals. These last are removed from the remainder of the mass by the centrifugal process, and we thus obtain a soft and unctuous paste which contains the essential elements of the milk, with some water still remaining. By drying the mass at a slight heat and *in vacuo*, the water is removed and the mass becomes solid. The present method of concentrating the milk has an advantage over others in that the resulting milk powder has not the taste of boiled milk which is an objectionable feature. Seeing that butter establishments already possess freezing plants, the new process will be a very practical one, as we can use the skimmed milk and can readily carry out the freezing, so that no special difficulty is found. The milk powder will thus be in a position to compete advantageously with condensed milk, which contains from 12 to 50 per cent of water. Milk tablets can also be made, and these can be combined with chocolate. Another use of the dried milk is for food for animals.

G. Charpy has observed certain phenomena in the case of steel resembling those described in the Scientific American by Prof. Cohen as the effect of strain disease or forcing disease. Stead has shown that the growth of the grains of ferrite in soft steel proceeds most rapidly between 650 deg. and 800 deg. C. Charpy has found that previous mechanical working of the metal causes a considerable increase in the rate of growth of the ferrite grains on subsequent annealing. For example in the case of two test pieces of a bar of soft steel of which one had been worked by means of a screw-plate, the difference in the growth of the ferrite grains on annealing for a certain time between 650 deg. and 800 deg. C. was so marked as to be visible to the naked eye on breaking the pieces of metal. In a given bar in which the mechanical working had been only superficial, the grains at the periphery were larger than those at the center. It is stated that if the annealing be prolonged sufficiently, the growth proceeds until in a piece of metal there is only a single large crystal of ferrite. This growth of the grains of ferrite does not notably affect the tensile strength of the steel, but renders the metal brittle. In some cases observed by Charpy, bars of steel which had been worked in a screw-plate gave good results in the bending test, but after annealing at about 650 deg. C., became so brittle that they broke on falling to the ground. Similar results are obtained with steel that has been worked in other ways, e. g., by drawing, cold-rolled plates, cold-forged or stamped steel, etc., and it is probable that many so-called abnormal failures of metallurgical products are due to effects such as those described.

ELECTRICAL NOTES.

A telephone line provided with phonographic transmitting and receiving apparatus has been installed in London. The object of this innovation is to make it possible to send a telephone message to a person who is not, at the moment, within reach of his telephone. The person called finds, on returning to his home or office, a phonographic record of the telephone message which was sent during his absence, and his phonograph reproduces the message from the record. This result was sought and obtained, in principle, by Poulsen, the Danish physicist, who has perfected the method of producing sustained electric waves by means of the singing arc. Poulsen's telegraphone, which was exhibited in Paris in 1900, is an electromagnetic phonograph which can readily be applied to the registration of telephone messages. The record is made on a ribbon of steel, which moves between the poles of an electromagnet and receives and preserves a magnetic impression of the words spoken into a microphone connected with the electromagnet.

Messrs. W. M. Thornton and E. Bowden have made a study of the ignition of coal dust by single electric flashes. The results of experiments on the ignition of a mixture of three typical coal-dusts from different seams of the Birtley Collieries are given in a series of tables and curves. The values of the smallest current, in amperes, capable of igniting a mixture of coal-dust and air, when interrupted by a quick-break switch, are summarized in the following table:

Volts.	Amperes.				Alternating Current Power-Factor.
	Direct Current.		Alternating Current.		
	Inductive.	Non-inductive.	Inductive.	Non-inductive.	
77	....	....	....	150	0.75
100	16.0	70.8	140.0	....	0.80
240	5.7	11.0	....	....	...
250	...	....	36.0	....	0.80
480	2.3	5.8	14.2	....	0.81
635	...	....	5.2	...	0.83

The author discusses, on the basis of his results, the most suitable conditions for the safe use of electricity in collieries.

TRADE NOTES AND FORMULÆ.

Bottle Wax (Gray).—	I.	II.	III.
Thick turpentine	2.	2.5	2.75
American rosin	2.	2.5	2.75
Shellac	1.	1.	1.
Oil of turpentine	0.75	0.75	0.75
Infusorial earth	1.	1.5	1.75
Chalk	1.5	2.	2.5
White lead	1.5	1.5	1.5
Lamp-black	0.25	0.25	0.25

Green Bottle Wax.—	I.		II.		III.	
Thick turpentine	2.5	2.5	2.5	2.5	2.5	2.5
American rosin	2.5	2.5	2.5	2.5	2.5	2.5
Shellac	1.	1.	0.75	0.75	0.75	0.75
Oil of turpentine	1.	1.	1.	1.	1.	1.
Infusorial earth	1.5	1.5	2.	2.5	2.5	2.5
Berlin blue	1.5	..	1.5	..	1.5	..
Chrome yellow	2.5	..	2.5	..	2.5	..
Ocher	..	..	..	0.5	..	0.5
Chrome green	..	2.	..	2.	..	2.
Heavy spar	3.	3.	4.	4.	4.5	4.5

Orange Bottle Wax.—	I.	II.	III.
Thick turpentine	2.75	2.75	2.75
American rosin	2.75	2.75	2.75
Shellac	1.	0.75	0.75
Oil of turpentine	1.	1.	1.
Infusional earth	1.	1.5	2.
Chalk	2.	2.5	3.
Orange chrome yellow	1.	1.	0.5
Orange ocher	1.	1.5	2.

Red Bottle Wax.—	I.	II.	III.
Thick turpentine	2.	2.25	2.5
American rosin	0.5	2.75	2.5
Shellac	0.5	0.75	0.5
Oil of turpentine	0.5	0.75	0.75
Infusorial earth	0.5	1.	1.5
Heavy spar	2.	2.5	3.
Red lead	0.5	0.5	0.5
English red	1.	1.	1.
Bole	0.5	0.5	0.5

Production of Gold Bronze.—Melt 2 parts of pure tin in a crucible and add 1 part of quicksilver, heated so that it is just beginning to fume. After cooling, the amalgam is reduced to a fine powder and intimately mixed with 1 part chloride of ammonia and 1 part flowers of sulphur; hereupon place the mixture in a glass flask, or a retort, which must be closed and set in the sand bath. Heating must be carried so far as to cause the escape of vapors, which collect in the upper part of the vessel. As soon as sublimation ceases, the vessel is removed from the sand bath and allowed to cool. The upper part will be found to form a bronze of the brightest gold shade, the lower portion consists of sal ammoniac and cinnabar.

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